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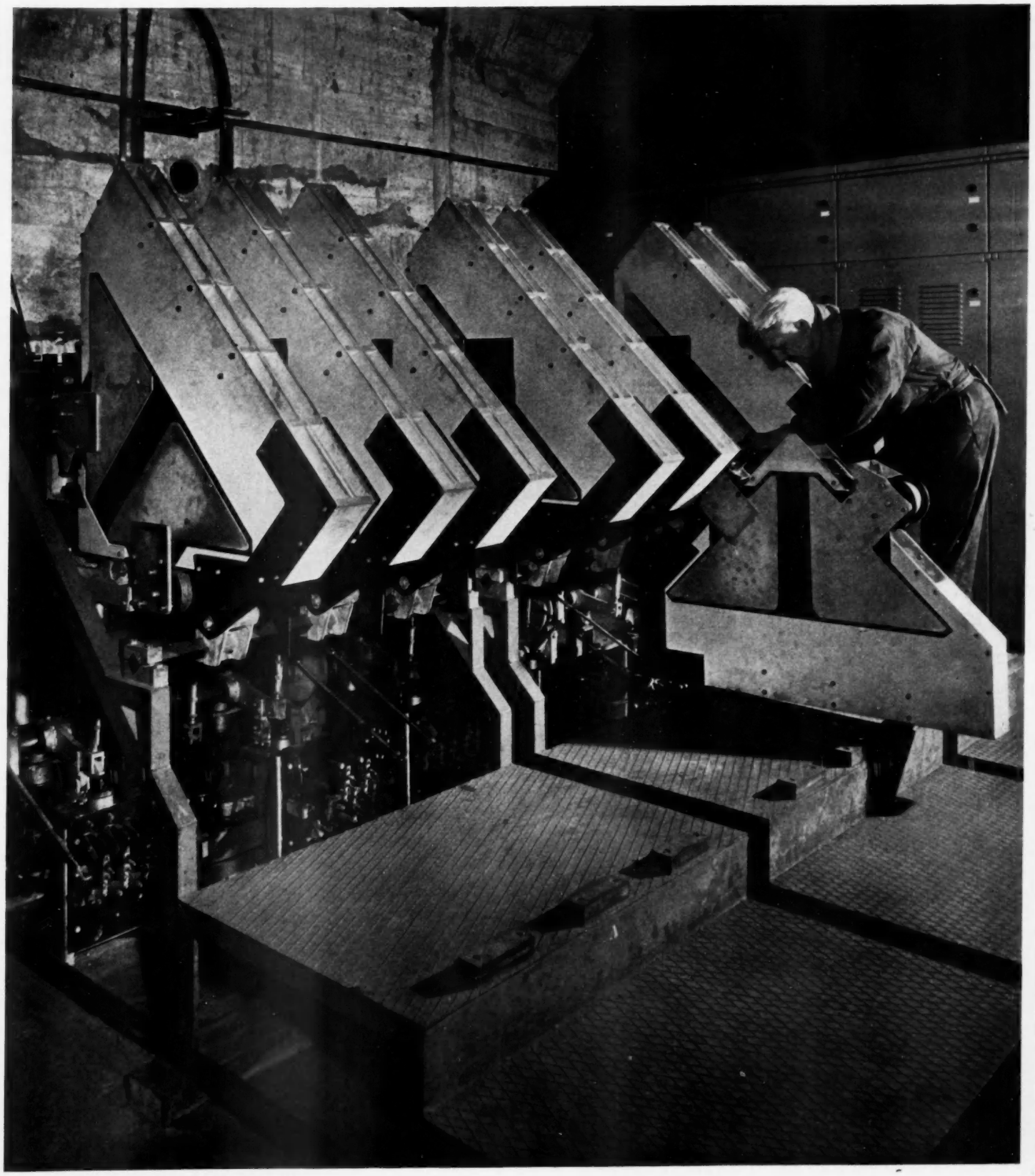

A BANK OF CONTACTORS

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ENGINEERING

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THE BARE PLATFORM

MANY a motorist, until a few months ago, boasted that he never travelled by train. But petrol rationing in Britain has put the clock back. He now sits staring out of the carriage window, chafing at the enforced inconvenience—or maybe enjoying the solitude and the relief from the responsibility of driving. He, and thousands like him, increased the railways' passenger traffic receipts by 22 per cent. in the first four weeks of this year. An increase of this size was beyond the wildest dreams of the British Transport Commission. If so much traffic can be obtained as a windfall, how much could be obtained by a full study of factors that cause a motorist to leave his car in the garage and buy a railway ticket? There is more to it than petrol rationing.

For many motorists there is something satisfying about the routine of driving. A private car is like a well trained dog: it is friendly, it obeys commands, it is part of the home, it has a certain prestige value. As no one is at his best first thing in the morning it is more tempting to step into the privacy of a motor-car, where suitcase, overcoat, papers, and other travelling appliances can be strewn about, than to run the gauntlet of a railway station and enter the harsh environment of a carriage. Just as it is easier to sleep in one's own bed than in a strange one, so the person-shaped seat of a car is more inviting than the uncertainty of a seat provided by British Railways. In other countries passengers are said to be more communicative and sociable; they are soon conversing with their fellow travellers, wiling away the time with agreeable chatter. But in Britain, every man withdraws into his shell, eyeing his neighbours with what appears to be suspicion but is more likely to be disdain. With such an insular nature, it is hardly surprising that he finds the facing-seat arrangement of British Railways embarrassing or at least irksome. To sit opposite a total stranger for several hours, with only one (or at most two) methods of temporary escape, is an ordeal that most Englishmen will go a long way to avoid (the Scots get over the difficulty by proposing a game of cards; the Welsh have done their best to keep railways out of Wales, except for some single-line tracks that are now chiefly of interest to "enthusiasts"; and the Irish never see each other in railway carriages because one or other of them always has a goose or a pig on his lap).

The open vestibule type of coach that is now quite common is no better; if anything it is worse. The wretched traveller now has a table between him and the man opposite—which raises nice problems of demarcation—and there is an intermittent stream of people passing through the carriage who seem to be infected with wanderlust, like caged animals, unable to sit quietly and unobtrusively. Seats facing all in one direction, like those in airliners, might eliminate the self-consciousness of travellers and spare them a depressing experience—that of not being able to look up from reading without unavoidably meeting the gaze of strangers.

The frustrating environment of railway travel contrasts sharply with the independence bestowed on the motorist by his private carriage. Whether it is a chauffeur driven limousine or an ancient Austin Seven, he enjoys a freedom of movement and timing which has strong attractions. He can watch the world go by, though it is himself who is doing the moving, and he is more or less shielded from the common gaze. All the characteristics of his nature are allowed full rein—meekness, aggressiveness; passive musing or active go-getting. Fortunately for British Railways there is another side to the picture: motoring can be boring and tiresome; a comfortable railway journey can be a welcome break. Though it is tempting to go by car in the morning, when a man's spirit is not always particularly high, the strain of driving is only too noticeable at the end of a long day at the wheel. It is then that a reserved seat in a railway carriage is seen in a rosy light. In the office or at home the telephone and other interruptions seem to conspire to prevent a man from working. But a few hours on a railway journey give an opportunity to read and ponder that is hardly obtainable anywhere else. Even a stopping train that takes its time across the countryside is then a delight:

> The steam hissed. Some one cleared his throat.
> No one left and no one came
> On the bare platform. What I saw
> Was Adlestrop—only a name.

Has anyone ever studied the psychology of railway travel? There is a rich field of discovery here that would undoubtedly give railway officers quantitative evidence on which to base the whole policy of operation and administration. Why, for instance, do the public generally regard London Transport's services as the last word in modern railway travel when, in fact, the trains are really painfully slow? The normal maximum speed between stops, on straight and level track, is a mere 37 m.p.h.—and many commuters stop at 20 or more stations both in the morning and the evening. The same speed on a steam train out in the open country would be exasperating, but a tube train running in a tunnel gives the impression of speed and urgency. All these psychological

factors are individually almost negligible, but collectively they are the conditions that determine the ratio of travel by train and travel by car. A comprehensive study of them could pay incalculable dividends to British Railways. The consequent increase in passenger traffic would give more badly needed revenue, and the increase in revenue would give railwaymen the kind of opportunity most of them have practically given up hope of ever enjoying.

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Plain Words

Policy makers often behave like certain tailors, who promise you a suit at very short notice, but don't bother to take your measurements. "Don't worry," they say when you try it on, "you'll grow into it." And so you may. But your socks will show as you walk, and every deep breath may cost a button. Thus, faced with a given situation—the results of the Suez venture, perhaps—a minister may take decision and a policy be evolved in a matter of hours; it may appear very reasonable, but it will remain to be seen whether or not it really fits the circumstances. Probably Britain's new defence proposals are sound and realistic—their intentions are certainly well directed—but one or two are sure to feel the pinch, some across the seat perhaps, others at the pocket.

Many companies have their production geared to a heavy defence expenditure; now they will presumably seek other uses for their capacity. Aircraft manufacturers may be able to concentrate on guided missiles, but others will transfer their attention to the domestic market. Has anything like adequate consideration been given to the repercussions and changes this is bound to bring about? How far is the fall in demand for military equipment, coupled with the oil situation and the credit squeeze, likely to lead to unemployment and idle factories? Is the Government ready with plans to absorb any redundant labour and production capacity arising from the new policy?

As yet no one knows. But someone should. No longer can we depend on the market system to make the necessary readjustment; there are already too many artificial influences at work. If one man, or perhaps two, can devise in an afternoon a plan to restore the balance of the entire Middle East, how can a rusty price mechanism respond in time to keep in step? To-day something more is necessary. Cyberneticians would call it feedback; we shall call it the tailor's tape measure. Thus in the case of the European free-trade proposal, the Federation of British Industries performed a comprehensive survey, which enabled the Government to measure the effect of such a plan on British firms. Policy could be based on knowledge. The quick decision of a Churchill resolved from a few factors carried in the head is invaluable in moments of crisis, but for the making of overall policy the careful long-term planning and attention to detail of an Alanbrooke may be preferable. A suit cut and stitched in haste may prove to be a straitjacket.

DEFENCE BY GUIDED WEAPON

By Jules Menken

The agreement about guided weapons which Mr. Duncan Sandys, the Minister of Defence, reached in Washington is welcome in principle. It is the more welcome because it rests on arrangements for collaboration in military research and development from which, Mr. Sandys told the House of Commons on February 6, both Britain and the United States have already derived considerable benefit, and which both countries have now decided to extend. It is true that agreements of this kind are not without danger. Britain's experience in collaborating with the United States over the development of the atomic bomb contains many elements which it would be undesirable to repeat. The story of landing-craft—which were mainly produced by the United States—and their bearing on Anglo-American strategic differences in the last couple of years of the Second World War also contains lessons which are relevant to-day. But in so far as the further co-operation now planned is full and generous-spirited on both sides, the detailed arrangements which lie ahead can bring important gains to both countries.

To infer from this new Anglo-American agreement that Britain's defence problems are now solved, or that easy economies in defence expenditure are in sight, would be very mistaken. Rather is the contrary the truth. Guided weapons are extremely expensive. During the current fiscal year (ending June 30, 1957) the United States is spending some 1,506 million dollars—say £510 million—on the major procurement and production of guided missiles, and during the next fiscal year such expenditure will rise to 2,039 million dollars—say, £730 million. By comparison, the current British budget (apart from subsequent economies or overspending) provides £517·5 million for the Royal Air Force, £479 million for the Army, and £351 million for the Royal Navy, before deducting American aid receipts which total £50 million for the three Services together. And even though it may be correctly urged that American outlays on guided weapons are much larger and more lavish than British expenditure need be, it is nevertheless true that these weapons are extremely costly instruments of warfare which in no circumstances can be provided cheaply.

The reasons why guided weapons by themselves cannot solve Britain's defence problems lie partly in the nature of these weapons and partly in the nature of war. Guided weapons are essentially missiles which can be hurled very far and very fast, which can (but need not) carry atomic or hydrogen war-heads, and which can be guided or directed more or less accurately to a target. Although their speed and range are new, as are modern possibilities of guidance, and although their destructive power with nuclear or thermonuclear warheads is unprecedented, guided missiles in the final analysis are nevertheless only missiles; and the whole history of warfare proves that missile weapons alone cannot solve the problems whose solution is sought by the use of physical force in war. To sum the matter up in a sentence, David could stun Goliath with a stone from his sling (one of the first recorded examples of a guided missile), but his real problem was not solved until he had cut off the head of the Philistine giant and held it up in triumph.

Because guided weapons are missiles, the fundamental question which they raise is, for what purposes are they to be used? Since the purposes of war and the uses of missiles in war-

fare are many, and since guided weapons are highly complex and refined products of modern science and engineering, it follows that these weapons are and must always be specialised. It follows further that a proper understanding of what guided weapons can and cannot do, and still more an understanding of the problems involved in their design, development, production, testing, and use, calls for study of the many branches and aspects of science and technology without the effective co-operation of which guided weapons cannot be made.

In this connection too little notice has so far been taken of a remarkable series of books to be completed in six volumes, of which the first three volumes have now appeared.* The editor, Captain Grayson Merrill, U.S. Navy, is a pioneer in guided missile technology who has taken a leading part in the guided missile programme of his own Service and is currently U.S. Navy Technical Director of the "Jupiter" intermediate-range ballistic missile project. The other authors—who include a number not named below—are leading specialists in their several fields. The text has been carefully reviewed to avoid disclosure of "classified" material. As a whole, the series, which is designed for the instruction of graduate students, professional engineers, and technical officers in the armed services, makes possible a fuller and better grasp of guided missile technology than any other publication in the field.

OPERATIONS RESEARCH

Both Captain Grayson Merrill and Dr. Harold Goldberg discuss the purposes for which missiles are to be used. The systematic investigation of this question involves the techniques of what is known as "operations research," which may be defined as the study of an assumed or existing guided missile system operating in an existing or an assumed tactical and strategic environment, in order to determine how best to meet a military requirement. Thus defined, operations research is not some esoteric knowledge, which even (as Captain Merrill warns his readers) "is by no means an exact science," but a technique of study which uses logic as its basic tool together with methods of investigation which from time immemorial have been "classic for the solution of mankind's problems: i.e., statement of the situation, separating fact from assumption, analysis of feasible courses of action, and choice of the best course of action."

Since any guided missile system, Captain Merrill warns us, "is intended to replace some other weapon-system, its operational superiority over existing systems must be established by operations research prior to and during its development, and by evaluation tests prior to its acceptance for service use." Captain Merrill adds the warning that "violation of this principle can lead to a great deal of wasted effort." It follows that the requirements of the armed services determine—so far as military considerations are concerned—the guided missiles that are wanted; while what is actually done will change in accordance with the changing needs of national strategy, current tactical doctrine, enemy developments as discovered by foreign intelligence, and the state of the guided missile art.

A HUNDRED QUESTIONS

Dr. Harold Goldberg carries this part of the analysis further. A typical questionnaire which seeks to determine the characteristics of the armament of a given guided missile may, he tells us, contain over a hundred questions. There are questions relating to the weapon system: for example, what is the type of missile (i.e., air-to-air, surface-to-air, surface-to-surface, etc.); what are the velocity and altitude range of the missile during the time it is attacking the target; what type of guidance system is used and what is its expected accuracy; what are the dimensions and shape of the missile and the allotment of space and weight for the armament; what are the dimensions and maximum movements of the missile's lift and control surfaces; what primary power sources are available in the missile for the armament system; what temperature rises will be encountered in the armament compartments as a result of aerodynamic or propulsion heating; what shock and vibration conditions exist at the armament locations in the missile; to what axial and lateral accelerations will the armament be subjected during the entire trajectory from launcher to target; what maximum perturbations of the missile axis from its trajectory may be expected; what system of propulsion is used; and what shock, vibration, and local temperature conditions relevant to the design of the armament compartments may therefore be expected (e.g., motor ionisation effects may adversely affect fusing)? Questions pertinent to the task of the weapon include the type or types of target that the missile is designed to destroy, the desired and minimum acceptable single-shot probabilities of kill, the maximum number of missiles that will be in the same guidance field at the same—or almost the same—time, whether the missile is to attack widely separated single targets or closely spaced formations, and what time limits are set from launching to the beginning and the end of the attack phase.

The complexity of operations research in the guided missile field is indicated, among other things, by the mathematical tools required. One tool is the theory of probability; and it is significant that the entire analysis of kills, which is central to judgment of the value of any particular guided weapon, depends on the mathematics of probability for its quantitative results. Very complex geometrical problems also arise. These are involved in the problem of vectoring an interceptor into a satisfactory position relative to the target, in computing the effect of air-interception radar range on forward hemisphere interception of high-speed targets, and in calculating what are called missile performance envelopes, which are required in operational analysis for certain types of target interception problems.

BEST TALENTS

Dr. Harold Goldberg sums up many of the most difficult problems of guided-missile technologists in his discussion of certain technical aspects of armament systems engineering. The basic problem, he points out, is so to design the components—warhead, fuse, and safety and arming mechanism—that they form an optimum and harmonious system which fits into the larger whole of the missile and of the weapons system of which the missile is only a part. A multitude of detailed problems is obviously involved, including reliability, cost, availability, safety, fusing, and others. "The resolution of problems such as these," Dr. Goldberg comments, "calls for the very best in the way of talents and knowledge on the part of the systems engineers. It is much harder to decide that a new fuse technique must be developed to fit a good warhead than to accept less than optimum performance by using some other warhead for which a fuse already exists. The person making this decision must balance a forecast of future success against a present certainty; this must be done in the face of the fact that the wisdom of the choice will not be proved or disproved for several years, and the fact that irreparable damage to the programme will result if he has miscalculated the chances of developing the required technique."

Dr. Goldberg continues: "This matter of blending existing art and data with extrapolations of technology to arrive at a decision of the best approach to a result to be achieved some years in the future is one of the aspects of technical systems engineering which calls for some of the ablest talent. The nice balance of realism and optimism required is a scarce commodity not easily come by. The entire art of warfare, as practiced by democracies, calls for this type of judgment, day in and day out; what number and kind of weapons will be needed to win a war which we will never start and for which we will not know the locale, our adversary, or his methods? The nation which plans a war for a specific time with a specific enemy has a better-defined problem. The democracy calls for much more vision on the part of its military planners."

DESIGN STUDIES

To what extent such gifts are called into action, even during preliminary design studies, appears from the items which usually receive consideration at the stage when the tactical features and doctrine of application of a missile have been established. As listed by Mr. Carl W. Besserer such items are:

(1) Selection of payload weight and form factor; safety, arming and fusing features.
(2) Selection of airborne guidance equipment.
(3) Selection of engine and related equipment; booster or auxiliary take-off devices.
(4) Preliminary aerodynamic analysis to establish:
  - Body configuration
  - Profile drag
  - Aerodynamic surface design, including
    - Planform
    - Lift-drag
    - Aspect ratio
    - Thickness
    - Taper
    - Mass balance
  - Wind tunnel programme (to establish characteristics of drag, lift, pitching-moment coefficients, boat-tailing, body configuration, wing-body and wing-fin interferences, downwash and upwash)
  - Stability derivatives
  - Aerodynamic requirements

(5) Loads analysis, for transient and steady states, to obtain:
  - Lift and drag loads
  - Pitching moments
  - Gust loads
  - Inertia loads
  - Torsional loads
  - Control system reactions
  - Oscillatory air forces
  - Diffuser or air duct pressures and drag
  - Centre of gravity movement during flight

(6) Structural analysis to provide:
  - Shear and moment diagrams
  - Pressure distribution

(7) Design, including preparation of layouts, to study:
  - General arrangement
  - Sectionalisation
  - Packaging
  - Flexibility of design
  - Control system actuation equipment
  - Material selection
  - Effect of concentrated masses and other loading conditions
  - Weight and balance; location of additional weight
  - Cost/producibility
  - Serviceability; provisions for test and maintenance
  - Evaluation of effect of tactical environment

(8) Follow-up analysis to provide:
  - Deflection studies

* *Principles of Guided Missile Design.* Edited by Grayson Merrill. Vol. 1: *Guidance.* By Arthur S. Locke and collaborators. Vol. 2: *Aerodynamics, Propulsion, Structures and Design Practice.* By E. A. Bonney, M. J. Zucrow and C. W. Besserer. Vol. 3: *Operations Research, Armament, Launching.* By G. Merrill, H. Goldberg and R. H. Helmholz. D. Van Nostrand Company, Incorporated, 120 Alexander-street, Princeton, N.J., U.S.A. (vol. 1, 12,50 dols.; vol. 2, 10 dols.; vol 3, 10 dols) and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2 (Vol. 1, 90*s.*; vol. 2, 75*s.*; vol. 3, 75*s.*).

Calculation of bending and torsional vibration modes
Evaluation of aero-elastic characteristics
Test requirements
Aerodynamic confirmation of design in the wind-tunnel
Estimate of reliability.

This list emphasises a fact which must be widely grasped if the development of guided weapons is to be commensurate with their possibilities, if what they can do—which is much, and highly differentiated from missile to missile—and what they cannot do—which is also much, and includes almost all the most difficult problems of war—are to be properly understood, and if provision is to be made for the heavy demands, technological, economic, and financial, which the growing use of these weapons must entail. This central fact is that a guided missile system is the most complex weapon so far designed by man. It is never the result of the efforts of any one individual, but always of a group. It requires co-operation to a degree never before faced in military technology. And this co-operation must be effective and sustained in a field where the rate of progress is tremendous, and in which data become obsolescent with alarming speed.

For Britain the practical importance of all this was plainly stated by Mr. Duncan Sandys in the House of Commons on February 13. The ultimate threat to these islands would come, he said, from Soviet nuclear ballistic missiles. The effectiveness of Britain's deterrent power, he went on, would depend on the possession by her of the same type of weapons. From these sombre but literally vital facts the responsibility may be measured which rests on the shoulders of all those actively concerned with the production and supply of the deterrent and essentially defensive guided missiles which Britain requires in order to live.

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Cramped Flight Testing

" Present restrictions on supersonic flying are hampering the development of supersonic aircraft in Britain," according to Mr F. W. Page, chief engineer of the Aircraft Division of the English Electric Company. He was opening a discussion after a lecture given before the Royal Aeronautical Society in London on February 14 by Mr. R. L. Lickley, chief engineer and technical director, and Mr. Peter Twiss, a test pilot and holder of the world speed record, both of the Fairey Aviation Company.

Mr. Page said he was referring only to new and unproved supersonic aircraft, and added that he thought that the situation was likely to become worse rather than better in the future. Many tests, particularly on an operational aeroplane, had to be carried out below 30,000 ft. or in dives.

Mr. Page illustrated the way English Electric was restricted in its test flying programme on the P.1 fighter by the need to avoid directing supersonic bangs over land. With the aircraft based at Warton aerodrome, near Preston, Lancashire, it was possible to fly supersonically over the Irish Sea in a straight line for only one minute without the risk of generating a supersonic bang over the land. " The area and duration of flight is very restricted and in the case of turning or diving supersonic flight, it is virtually impossible to avoid bangs being heard on occasions."

The restrictions which pilots had to observe were, he thought, an unfair burden to place on someone engaged on a difficult and hazardous job. The test area was well out to sea and he had heard it said that this deprived the pilot of his last remaining luxury, namely that if he had to abandon the aircraft, he should stand a reasonable chance of being rescued. Even leaving the personal element out of account, if something went wrong over the sea the chances of retrieving the wreckage were negligible.

Letters to the Editor

INTRODUCING EXPLOSIVES

SIR, In your article " Introducing Explosives," on page 66 of ENGINEERING for January 18, it is stated, at the end of the first column, that " Nobel overcame this difficulty [the detonation of nitroglycerine at will] by the invention of the mercury fulminate cap, the ancestor of the modern detonator, which was first mentioned in his patents dated 1864."

In this respect, I should like to point out that the mercury fulminate cap was well known in the firearms field long before this time; the credit for its invention having been given to Joshua Shaw in 1814. Two years later, leading English gunsmiths, such as Joseph Manton, James Purdey and Joseph Egg, were making weapons incorporating its use. The cap was so successful that, by 1825 to 1830, the flint lock was obsolete so far as the better-class types of guns and pistols were concerned.

Yours faithfully,

F. ROGERS.

17 Rosemary-crescent,
Wolverhampton.
February 12, 1957.

★ ★ ★

TURBO-GENERATOR EFFICIENCIES

SIR, May I, through the courtesy of your correspondence columns, comment on Mr. E. T. G. Emery's interesting contribution, published, under the above-mentioned title, on page 144 of your issue of February 1 last ?

In this article, in which it is shown how the " expected efficiency " of a turbo-generator can be calculated from formulae and steam tables, there are various references to papers by Dr. K. Baumann and myself. As Mr. Emery points out, the curves by Dr. Baumann and the writer indicate thermal efficiency variations relative to defined basis steam conditions and, in order to compare or determine heat consumptions of units at other conditions, it is necessary to fix the level of performance of a practical turbo-generator at the basis pressure and temperature. This is usually determined from test data in the same way as Mr. Emery has assessed the value of K in his formula from an analysis of a large number of British machines. Dr. Baumann's curves could be applied generally to units of 50 MW or so, and his general rule (published in 1921) that turbine efficiency increases by about 2 per cent. for each doubling of the output × speed factor still holds, as evidenced by a similar variation in Mr. Emery's value of K for units of up to 120 MW. Such experience as is available appears to confirm Mr. Emery's conclusions that the rate of gain in efficiency, due to increases in size, tends to decrease with the very large outputs which are usually associated with high steam pressures and, possibly, with cross-compounding.

The writer and his associates have found that much time can be saved by the use of Dr. Baumann's curves, as, for example, when collating " as run " test results made under operating conditions differing from the standard. Experience continues to confirm the high accuracy of these curves. Indeed, when it is possible to correct them for variations in leaving loss, velocity ratio, generator efficiency and other factors, the curves may be used over a wide range, and will yield results deviating from an average value by even less than that (of the order of one-half) recorded by Mr. Emery. The application of the curves is illustrated in a communication by the writer to the discussion on the paper by A. Howell and J. B. Jackson on Dunston " B " Station, published in the *Proceedings of the Institution of Mechanical Engineers*, vol. 167, page 105 (1953).

In any event, it will be recognised that the comparison of turbine-generator performances with a statistical average has its own hazards, especially in cases of extrapolation. A modern generating plant is a highly specialised development calling for a large capital outlay, and, with high fuel costs, a new turbine which provided only an " average " consumption would be neither fair to the customer nor enhance the prestige of the manufacturer. The economics of service of a particular turbine may justify a lower level than the ideal thermal efficiency technologically available; nevertheless, the best basis efficiency should still be used for comparison, with appropriate corrections for the higher leaving losses or reduced staging of the plant in question.

Yours faithfully,

J. C. LONDON,
Development Engineer.

Steam Turbine Engineering Department,
Metropolitan-Vickers Electrical Co., Ltd.,
Manchester, 17.
February 14, 1957.

★ ★ ★

FRUSTRATED LEADERS

SIR, I have read with interest Mr. Astley's letter in ENGINEERING for January 18, page 69, especially as I think he speaks from the other side of the fence. I am grateful, too, for his sympathy. But I can think of nothing more likely to make worse the situation I deplored in my original letter than to implement his recommendation that " Personnel management as a profession should continue to be given more and more scope. . . ."

This is just what is wrong. Personnel management is an art that should, of course, be acquired by anyone who has to exercise authority over others; but it should not be an end in itself. If Mr. Astley means only that personnel management should be deliberately studied and taught to those in authority, i.e., that the " profession " of personnel management should embrace only researchers and teachers or advisers, then I would be the last to disagree with him. But does he mean only that ?

What usually happens in practice is that what should be purely a service section, such as a staff or employment department, expands into, or becomes an appendage of, a personnel management section. The members of this section then come to wield executive authority in such matters as discipline, pay, promotion, etc., without having any direct responsibility for the results of their decisions. Moreover, their decisions are too often based on an inadequate knowledge of situations that they are not equipped by training or experience to understand.

The principle, Sir, is simple. The man with the responsibility should have the authority. The present tendency to whittle away this authority in favour of specialist departments, which should be service or advisory departments only, is a tendency that it is urgent should be reversed.

I remain, Sir,

Yours faithfully,

H. W. S. MARSHALL.

P.O. Box 1,
Kirkuk,
'Iraq.
February 6, 1957.

★ ★ ★

CEMENT PRODUCTION IN QATAR

SIR, Preliminary results of a detailed geological survey being conducted for the Government of Qatar by the Associated Drilling Supply Company (Overseas) Limited indicate that adequate natural resources exist in Qatar for the manufacture of high quality Portland cement. There are indications that reserves immediately exploitable at a low cost are sufficient for at least 50 years' working, at a production rate of from 200 to 300 tons of cement a day, by the dry process. Supplies of cheap fuel are available near at hand, as the main limestone area is within 20 miles of the centre of gravity of the Qatar Petroleum Company's Dukhan Oilfield, from which natural

gas can be obtained. It is expected that sweet water will also be found within a reasonable distance of the proposed site.

Market research in the Persian Gulf area has shown that there is ample scope for the use of high quality Portland cement manufactured locally. At present, Qatar itself imports from 40,000 to 60,000 tons per annum, so that a plant of that size should be able to capture a considerable export market locally. The Government of Qatar is accordingly considering the establishment of a cement works and this action may well lead to a wider scheme of industrialisation, aimed at providing employment for Qataris in other directions than the oil industry.

Inquiries from Portland cement manufacturers, or associated companies, who might be interested in participating in the above scheme would receive consideration.

Yours faithfully,
H. T. HALE,
State Engineer.

Government of Qatar,
Doha,
Persian Gulf.
February 11, 1957.

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COUPLING TUBES

SIR, The new high pressure pipe coupling described on page 170, in your issue of February 8, 1957, has admirable simplicity and avoids the difficulties encountered when dealing with spigot-type joints in long or stiff pipe systems.

It is, however, quite feasible that such a coupling might be used on work without either, or even both, of the essential inner sleeves present; an omission which cannot easily be checked. At higher pressures, the pipe, particularly a thin-walled one, would then " blow out " of the connecting rings in their present form. It would be interesting to know what the manufacturer's attitude is to this aspect, which limits the practical value of the invention.

Yours faithfully,
J. J. GRANVILLE.

31 Park-lane,
Northwich,
Cheshire.
February 14, 1957.

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Obituary

MR. A. E. CULLEY

We regret to record the death on February 5, at Norwich, of Mr. A. E. Culley, formerly Editor of *Machinery Market*. Mr. Culley, who was in his 80th year, relinquished his editorship as recently as 1955.

Alfred Edwin Culley had a long and varied engineering career before turning to journalism. He was born on August 13, 1877, and received his general education at Leys School, Cambridge. His apprenticeship was served partly with J. and J. Colman, Limited, Norwich, with whom he served from 1893 to 1895, and then, until 1898, with Clarke, Chapman and Company, Limited, Gateshead. He then attended the Central Technical College, South Kensington, taking the civil and mechanical engineering course, and, after gaining the diploma of A.C.G.I. in 1900, joined the staff of the late Mr. C. H. Merz in Newcastle-upon-Tyne.

After experience with a number of firms, including some years with Mr. W. Aubrey-Thomas, consulting engineer, of Liverpool, he returned, in 1921, to consulting practice on his own account. He joined the editorial department of *Machinery Market* in 1926, and was appointed Editor five years later.

Mr. Culley was an Associate Member of the Institution of Civil Engineers, to which he had belonged for nearly 53 years. Widely read and extensively travelled, he will be remembered with a high regard as a friendly and discerning observer of men and things.

Weekly Survey

Cover Picture: *The bank of contactors shown in this illustration is designed to control an* 11,000 *volt supply to a motor. By their means it can be reversed and dynamic braking brought into operation.*

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Engineers on the Budget

February is lobbying time on the Budget. There is an added piquancy to the exercise this year since Mr. Peter Thorneycroft has taken over the Exchequer at the beginning of the open season. The Engineering Industries Association has submitted a number of suggestions to the new Chancellor as is its usual practice.

The Association views with alarm the decreasing rate of expansion in expenditure by industry on capital goods. It considers that the policy of disinflation has now outlived its purpose and that the Government's policy has brought to a standstill the economic system's increasing productivity. The Association considers that restriction of credit and the ensuing shortage of funds has restricted industry's export effort. It thinks that the question of banking facilities for long-term export credits and the functions of the Export Credits Guarantee Department need reviewing. Taxation is considered to be too high and any further increases in this direction, imposed to establish a large Budget surplus, are deprecated. The Association favours the removal of the recent petrol tax increase, the substitution of a sales tax for the present purchase tax, restoration of investment allowances, abolition of the tax on undistributed profits, certain other changes in profits tax, raising the level for earned income relief and raising the minimum level of surtax.

This memorandum covers a great deal of ground. More approval can be given to some of its detailed proposals than to some of its broad assertions. It is much more convincing to argue for an incentive Budget based on better treatment for profits and surtax payers than to assert categorically that the need for disinflation is over. It is becoming clear that the effects of the Suez crisis are going to be fairly slow but insidious on the economy as a whole. The cost of living is now rising and unemployment and shorter working hours are spreading. A relaxation of the credit squeeze will not do much to put these things right. They can only be remedied by a larger inflow of fuel oil and an end to the dislocation of shipping. The balance of payments situation remains obscure and the visible trade balance for January, although not alarming in its picture, gives no grounds at the moment for optimism about the trend of imports and exports. It is, in fact, exceedingly difficult to make broad recommendations about the taxation and credit policy until the Government shows its hand on defence expenditure.

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British Enterprise in Europe

The success of the Massey-Harris-Ferguson products in Western European markets shows the high competitive strength of British agricultural machinery. Despite an import duty of 30 per cent., over 1,500 Ferguson tractors were exported from Coventry for sale in Germany last year " in the face of stiff competition from the numerous and most efficient German tractor manufacturers." The company's combine-harvester factory at Eschwege (just inside the West German zone) is producing small combines at the rate of 30 a day, and may expand to 50 units over 24 hours. Some 2,500 of these self-propelled combines have been ordered for France for delivery in 1957; several thousands have been sold outside Germany since output began in January, 1956.

In France, the Cie. Massey-Harris-Ferguson are the leading manufacturers of agricultural tractors. In the year ending October, 1956, nearly 29,000 Massey-Harris and Ferguson tractors were made (by the Société Standard-Hotchkiss), representing about 37 per cent. of total French production. Since operations began in 1952, some 87,000 tractors of both makes have been produced. At the present time one in every four of the 403,250 agricultural tractors in use on French farms are either Massey-Harris or Ferguson.

The success achieved by the company, both in their exports to Western Europe and in their local manufacture in Germany and France, shows that British products of advanced design which benefit from the advantages of large-scale production are highly competitive anywhere on the Continent. It is very encouraging to those who are now considering the part they might play in a free trade area. There is nothing magical about German manufacturing methods, or insuperable in their relatively low labour costs. For the efficient, well equipped factory operating on a large scale the West European market could be thrown wide open by any significant reductions of import duties and quotas.

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Record Oil Equipment Orders

Orders received in 1956 by manufacturers of oil equipment reached the record level of £153·7 million. This was almost 25 per cent. higher than the previous year's total. These figures have been published by the Council of British Manufacturers of Petroleum Equipment.

There are a number of encouraging features about this situation. In the first place, the flow of orders was maintained in the last quarter of the year. In fact, they were running 30 per cent. higher than in the corresponding quarter of 1955. Thus the oil equipment industry was not hampered by the credit squeeze so far as the order book was concerned. A second feature is the continuing success by British companies in providing specialised drilling and production equipment. For long enough the oil-field side of the industry was considered to be the perquisite of the American oil equipment industry. Since the war, however, the British industry has made steady if unspectacular progress in this direction. This is an excellent development. In the years ahead, increasing oil supplies will be required and the world will have to drill and bore deeper to get them. It is inevitable that extraction costs per barrel of oil (especially in North and South America) will rise significantly.

Meanwhile other sections of the industry have done well. The largest group of orders for the industry have been in tubulars, pipe fittings and valves. Tankage orders and chemicals have also been buoyant. As with the oil-fields side, the transportation and refining side of the petroleum industry is likely to require increasing quantities of equipment. The oil in many cases is not only coming from deeper wells but also over longer distances.

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Profitability of Engineering

One of the most interesting annual exercises by the tax authorities is the Statistical Appendix on Companies to the annual report of the Commissioners of Inland Revenue. This appendix gives the relation of profits to turnover for key industries. The calculations are based on the tax assessment returns and they are in consequence somewhat out of date. The latest exercise by the Inland Revenue brings the picture up to date to 1954-55. This means in effect that the statistics relate to the calendar year 1953. The highest percentage of profits to turnover is found in mining and quarrying (excluding coal), transport (excluding railways and shipping),

non-metal mining (excluding coal), paper and printing, electrical engineering and other engineering (the last excluding vehicles). The range within this group is not very great. Mines and quarries come out in the latest year at 17·5 per cent. while shipbuilding and non-electrical engineering are given as 13·3 per cent.

It will be noticed that the engineering groups are ahead of vehicles (which are shown separately at 9·5 per cent.), chemicals, metal goods and iron and steel. The figures must be treated with some care, however. There is reason to think, for instance, that the spread of the percentage figure in electrical engineering is not close to the average given. It is likely that a true picture would be of very high percentages on turnover for small companies and low percentages on turnover for some of the giants in industry. Comparisons must also be cautious between such industries as shipbuilding and vehicles. Shipbuilding may show a higher percentage profit on turnover than vehicles but it turns over its working capital much more slowly, and its turnover is difficult to adjust over short periods in the face of changing conditions. The burden of overhead costs is thus heavier and more inflexible than on motor vehicles and the risk is therefore greater.

Nevertheless, the figures suggest that the engineering industry remains one of the more profitable activities per unit of output. This should be so, for the general prosperity of industry since the war has been built up very much on a booming engineering industry.

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De-rating and Industry

The Government are making an effort to bring a little more sense and order into local authority finance. Wherever practicable existing grants from the central government to local authorities for specific services are to be replaced by a general grant. The effect of this will be to decrease the temptation of the central government to control the minutiae of local government administration and give the latter greater financial autonomy. This is gain as far as it goes. The purse strings are to be loosened, but there is not really much more inside the purse. The Government has turned down any bold ideas about increasing the direct revenue of the local authorities by allowing them to levy a local tax of some sort.

One consequence of the change will be for industry to pay 50 per cent. of the net annual rateable value compared with 25 per cent. at present. This must mean an increase in industry's rate burden on top of the large increases in industrial rates which followed the recent revaluation. The Government is in fact trying to get away from the mass of anomalies which were created in favour of industry when de-rating was introduced at the time of the great depression.

There is, however, a good deal of opportunism about the whole affair in spite of half-hearted efforts to get nearer a clarification of principle. Agriculture, for instance, is to keep its de-rating percentage unaltered. The additional burden which will fall on industry has brought a quick rejoinder from the Federation of British Industries. Remarking that industry will require time to work out the complex implications of the change, the F.B.I. says that the great need in re-organising local government finance is to place all property on a uniform basis of valuation. The basis of industrial systems, they say, should be re-examined in the light of this revised system. Certainly it is bad in principle to have different systems and complicated rebates for special circumstances. There are in fact several basic questions which the Government proposals and the special pleading which they will stimulate can hardly help to clarify. These are:—How independent of the central government should local authorities be financially? What public services should be maintained and paid for locally and what proportion of the expense should each type of local taxpayer carry?

A Case for More Competition

The latest report of the Monopolies Commission on the supply of electronic valves and cathode ray tubes is probably the most significant indictment of restrictive practices yet published. The Commission do not attempt to interpret the facts contained in their report in terms of the public interest. This has ceased to be their function since the passing of the Restrictive Trade Pracices Act. Apart from being told that the industry operated as a monopoly (until September 1956) the reader is left to draw his own conclusions. When the inquiry began towards the end of 1954, the British Radio Valve Manufacturers' Association (the B.V.A.)—whose members accounted for over 90 per cent. of total output—operated a list of restrictive practices which included common retail prices, collective price maintenance, agreed discriminatory prices and discounts, exclusive dealing arrangements with customers, restrictions on the freedom to import, higher prices for replacement valves and tubes than for those sold for initial equipment, and so forth. As the inquiry was drawing to a close the B.V.A. amended their regulations to eliminate price fixing by agreement and collective re-sale price maintenance.

The main point of interest is the dominant position of Mullard Limited and their very strong competitive standing. This company, a fully-owned subsidiary of N.V. Philips of Eindhoven, accounted for about 60 per cent. of the association's sales of both valves and tubes. The figures quoted in the report suggest that none of their competitors even approached their efficiency. Over the four years to 1954 Mullard's profits as a proportion of capital (valued at replacement cost) fell from 39·2 to 36·3 per cent.: the corresponding figures for other manufacturers fell from 17 to 0·5 per cent. Those companies included Edison Swan, Ferranti, G.E.C., E.M.I. and Standard Telephones and Cables. There are large imports of valves (22 per cent. of U.K. production in 1955) despite a 33⅓ per cent. import duty. Mullard's import a large proportion of their requirements from their parent company, Philips, frequently at prices of 30 to 45 per cent. of the retail price. All in all the British radio and television industry appears to have paid a high price for its valves and tubes in the past. What it will have to pay in the future would seem to depend almost entirely on the price policy adopted by Mullard, for they alone possess a sufficient profit margin to cut prices substantially. But to do this would presumably further extend their share of the market until there are few other suppliers. Is the cure therefore more monopoly or less.

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Price Policy for Steel

Two steel makers have recently given their views on prices and raw-material supplies. In each case they discuss the problem in relation to the industry's future development. Sir John James, chairman of the Lancashire Steel Corporation, criticises the "arbitrary price-fixing policies in the steel industry." In his view they have a restrictive effect on expansion, and are the main cause for "the extreme and continuing shortage of steel plates which has hampered the efforts of our shipbuilders to give reasonable delivery against foreign competition, and the shortage of heavy sections which has delayed construction urgently needed for the expansion of the country's basic industries." For one of his company's main products, prices have been fixed on a basis which, after depreciation but before tax, allows a return of some 9 per cent. on the full replacement cost of new plant. After tax only 4½ per cent. is left to stimulate the investor. Sir John argues strongly for a "complete review and new thinking over the principles on which price fixing in the steel industry is based."

Sir Andrew McCance, chairman of Colvilles Limited, warns that raw material supplies could seriously interfere with the industry's expansion plans. World reserves of iron ore are ample "for many years to come," but the distant location of new deposits and Britain's inability to participate in their development on a large scale (due to shortage of capital for foreign investment) combine to make our sources of supply less secure. Sir Andrew foresees continued and rapid growth in the world demand for steel, and therefore expects growing competition for raw materials. He points out that in this respect "the question of determining the rate of progress lies in other hands" and warns that during the next decade some slowing down in the rate of construction of new steel capacity may be brought about by "the rate of progress in the development of raw material supplies."

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Power for a Nation

Electricity in the national economy is the theme of the ninth British Electrical Power Convention which is to be held at Eastbourne from June 17 to 21. The important role that electric power does in fact play needs little emphasis. British industrial development is dependent on the availability of adequate supplies of power. The increase in power consumption that has already taken place gives some idea of the background to the forthcoming conference. Whereas, in the period 1946-47, 17,941 million kWh were generated, the period 1955-56 saw the generation of 32,431 million kWh; and it is now broadly accepted that the demand for electrical power doubles every ten years.

Aspects of generation are considered in 3 of the 17 papers that are to be read, and while nuclear energy is considered in a separate paper, it too, no doubt, will be chiefly concerned with power generation. As much time is to be devoted to the nuclear energy paper as is spent on all three of the other papers put together. A morning is given over to six papers on distribution and transmission, with particular reference to higher voltages. The remaining seven papers are concerned with electricity from the point of view of the industrial and domestic consumer. An interesting point is that as much time is given to papers of a domestic nature, collectively termed "houses into homes," as is scheduled for those on generation—half a day in each case. The convention, under the presidency of Sir Josiah Eccles, deputy chairman (operations) of the Central Electricity Authority, will be opened by him on June 18, when he will deliver his presidential address. The convention will be held in the Winter Gardens, while in the adjoining grounds will be situated an electrical exhibition occupying about 32,000 sq. ft. This exhibition will be opened by the president on the evening of June 17.

The increasing need for electricity can only be met in two ways: more power stations must be built or the existing ones must be made more efficient. There appears to be scope for the second method since 15 per cent. of our generating plant is over 25 years old. However, the manufacturers of power station plant have engineers well capable of meeting this challenge as no doubt the conference will show.

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Communications on Rail

The first commercial teleprinter network on British Railways was introduced last week by the London Midland Region. For the time being the service is limited to goods traffic but it is hoped to use a teleprinter system for passsenger traffic in due course.

The new service gives immediate contact between the chief commercial manager of the London Midland Region and the district goods managers in the main stations. The installation

is expected to be particularly important for rates quotations, the tracing of missing goods, advice of special transits and for expediting instructions. The message is typed on to a Creed teleprinter machine at either end and is transmitted to a relay point at Birmingham where it is relayed by automatic transmission to Liverpool, Manchester, Euston or Broad Street, whichever the case may be. The district manager can then transmit to his major goods yards by means of Desk Fax equipment also supplied by Creed and Company. There will thus be teleprinter connections between 5 district headquarters through Birmingham (the latter is of course both the relay re-transmission point and a district headquarters) and facsimile connections from the main goods yards to the district office.

Important as this development is for the increased efficiency of the freight traffic service on the Midland Region network, it is even more important as a sign of the times. The hope for an efficient and competitive railway system which can hold its own against air and road travel depends upon a very much higher amount of capital per worker employed by the railways. This applies both to office services and non-clerical grades. The starvation diet of capital which the railways have endured for many years has left a huge backlog of work to be done in installing modern techniques of communication and management.

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Emphasis on Research

Looking ahead, a company's principal concern must be for "an intensification of design, development, and research." Captain A. R. S. Nutting, chairman of Westinghouse Brake and Signal Company, emphasised in his annual report that this was one of the main factors likely to determine his company's prospects for the future. Westinghouse have greatly benefited from the re-equipment programme of British Railways and have also recorded a major rise in export business. The orders in hand, which required deliveries spread over several years, and tenders outstanding suggest that the company and several of their subsidiaries can "base their plans on a continuance of demand for their products well beyond 1957."

The Group's main products are railway brakes, signalling and colliery equipment, and rectifiers. Captain Nutting reported improved and greater productive capacity as well as record trading results, but he underlined the need for "a careful watch on all these factors and pressures which result in rising costs without compensating ameliorations, such as increased production and sales to offset these increases." It was very easy, he said, for a company to price themselves out of world markets. For this reason continuous progress in research and development to secure and hold a technical lead, was vital.

Words of warning were sounded on the proposal to secure the economic integration of Western Europe. Captain Nutting considered that it required "the most careful study by the whole of British industry, including the trade unions, before any commitments are made."

Another manufacturing group to emphasise the importance of research was Associated Engineering Holdings, Limited. Their considerable dependence on the motor industry (pistons and piston rings, cylinder liners, radiators and other engine components) has stimulated research in other fields. Gas turbine blades is one of the group's new products, now made in a factory (Hepworth and Grandage at Yeadon) employing over 800 people. Superchargers, nitrided bushes, and industrial space heaters are some of the other new products recently added to the company's range of output. In order to widen it still further "a large part of the work of the research and development departments is devoted to the investigation of new processes and inventions which might offer opportunities for the manufacture of fresh products."

TRAINING NAVAL ARCHITECTS AND MARINE ENGINEERS

I.N.A. Symposium Sees Bright Career Prospects

Concluded from page 223

The discussion on the papers presented in the Symposium held in London on February 6 by the Institution of Naval Architects on "The Education and Training of Naval Architects and Marine Engineers" was opened by Mr. E. L. Champness, C.B.E., who disagreed with Professor Telfer's implication that Britain's loss of supremacy in shipbuilding output was a consequence of insufficient appreciation of science. Counting professorial heads was not a sound criterion. What was the aim of the Symposium? Would the younger men present say what deficiencies in training they had experienced? In a former discussion on the subject, there was an allusion to "half-baked Ephraims"; care must be taken that any scheme of education proposed did not produce too many "Ephraims"—as was hinted in the 1939 report. (The reference is apparently to *Hosea*, vii, 8: "Ephraim is a cake not turned."—*Ed., E.*) Recruiting for the Royal Corps of Naval Constructors might be easier if, in the title of his paper, Professor Palmer could have referred to "Constructor Officers for the Royal Navy."

UNIVERSITY ENTRANTS

Sir Victor Shepheard, C.B., R.C.N.C., agreed with Dr. Telfer on most points. Last year the R.C.N.C. did not get a single recruit from the universities. The shortage of good technical men, he considered, resulted from neglect of science in the public and grammar schools. There should be more courses in naval architecture in universities, but it was hopeless to start them unless more and better candidates came from the schools.

Mr. H. S. Pengelly, R.C.N.C., said that young men who fitted the specification for the R.C.N.C. could readily find better openings elsewhere. The shipping and shipbuilding firms did not offer enough in the way of careers and status to young trained naval architects.

Mr. John Brown, B.Sc., asked for a definition of the true "sandwich system"; he would prefer one which gave periods of six months alternately in the shipyard and the university or college. That a student was brought into direct contact with the workpeople was a great advantage of sandwich systems, but did they allow enough time in the university? The Glasgow University entrance requirement of a second language kept out some good men, especially those of the National Certificate type, which was a real loss.

Mr. J. Lenaghan did not accept the view that the shipbuilding industry was doing nothing to train its young men; his own firm (the Fairfield Shipbuilding and Engineering Company) was doing a great deal. Nor did he agree that every shipyard should have its own research department; it was not research, but development work, that should be carried on in the shipyards. Three university courses were enough, i.e., Glasgow, Durham and London (the Royal Naval College). The Royal Naval College was too insular; it should train men for the industry also—without too much mathematics. The universities should devote more attention to the teaching of English. The sandwich system struck a good balance between science and practice, but the emphasis must be on producing a scientifically trained practical shipbuilder. The shipyards should provide more drawing-office openings for graduates.

Mr. C. H. Taylor-Cook regretted that the papers made such scant mention of part-time work, and of the work of the technical colleges. Was university education really the best for the required purpose? The university graduate, on entering industry, was usually out of his depth. More marine engineers might study for the Extra Chief certificate if they had not to live on their savings while doing so.

Mr. L. Woollard, M.A., thought that the new method of entry to the Royal Naval College and the R.C.N.C., directly from grammar schools, was not sufficiently widely known; it was a very significant new departure. Dr. Telfer had overstated his case; there was no lack of interest in the shipyards. He approved the suggestion that the student should be given prepared notes.

Mr. A. J. Sims, O.B.E., R.C.N.C., said that the real problem was how to mix the university training with the practical. The nature of apprenticeship was changing, and in future it would not give the necessary grounding for the officer class. Fundamentals must be taught convincingly and accurately; if that was done, it did not matter if the notes were old. How many examiners realised, however, that, in their questions, they were setting the future pattern for studies?

Professor G. H. Chambers, D.S.C., said that the seagoing engineer was not the only one to be considered. New kinds of machinery were coming forward—gas turbines, free-piston engines, nuclear plant, etc.—and someone had to advise the shipowner on the type to adopt. Such a man must have a training wider than that of the seagoing engineer. The best place to gain such knowledge was the university, but the course must be dovetailed with practical and sea experience.

Mr. J. D. Calder said that one Clyde yard, building small craft, released its apprentices to study for one month in six instead of one day a week; this produced good results. Dr. Telfer's proposal for more university courses was on a shaky basis. To allocate professors on a tonnage basis was not sound; the prevailing nationalistic tendencies of small countries played a part. He supported the loose-leaf tutorial scheme, and the contention that drawing-office work should be learned in the shipyard.

PROMOTION PROBLEMS

Lord Runciman said that Dr. Dorey's remarks on marine engineers who left the sea applied also to deck officers; was the sea losing its attraction? With regard to research—there was a limit to the numbers who could be usefully employed, and he would deprecate research merely for the sake of researching. There were still, however, very attractive opportunities; when young men were promised advancement, however, keeping that promise might mean getting rid of older men while they were still useful. It was a difficult problem.

Lord Runciman's remarks concluded the morning session. The discussion was resumed by Professor H. E. Jaeger, of Delft, Holland, with a comparison between the curriculum in naval architecture and mechanical engineering at Delft and those in the United Kingdom. The Dutch student worked several more hours in the week, but he could take as many years as he wished over the course, if he failed to graduate in the minimum of four or five. Britain needed more professors, but three universities would be enough if Glasgow, Durham and the Royal Naval College had two professors each.

Mr. D. M. Reid thought that courses should pay more attention to operation and maintenance. One trouble was that there were too few really good apprentices. In the Poplar Technical College, fewer than 50 per cent. had had any training in a marine engine works, and only 10 per cent. had even an Ordinary National Certificate.

Dr. J. F. Allan quoted the President's statement,

at a previous meeting, that it was not possible to buy inspiration and judgment and leadership cheaply. The university should develop those characteristics. In the past, the industry had been led by people who were not highly trained technically, but now it was becoming more and more desirable that the leaders should have a good grasp of the technical aspects. It was for the universities to bring forward the leader types, but industry must offer them suitable rewards. How many graduates did the shipbuilding industry really require? He thought Dr. Telfer's proposals to be rather ambitious.

Commander W. H. Stewart, R.N., said that there were two distinct types of training, for naval architects and for marine engineers, so that some sort of compromise was inescapable; how were the right proportions to be found? Some officers must be equipped to diagnose and remedy troubles; that required clear thinking and good power of expression. A natural interest was the best incentive to study. The prospect of a good career was the next best, and this prospect should be made manifest to the student from the start.

SHIPBUILDING EDUCATION EXPANDING

In reply to the discussion, Professor Telfer expressed satisfaction at the controversy that his proposals had aroused. Mr. Lenaghan's point about reclassification of staff duties was a good one. He agreed with Mr. Sims that the professors should themselves teach the fundamentals but at what point should they stop? It was inevitable that there should be more courses in the future. Finding the students was no obstacle; shipbuilding had a brighter future now than ever before, and students would continue to flow into it. He hoped that a new Education Committee might be set up as an outcome of the Symposium.

Professor A. M. Robb said that Glasgow University would fight to the end to defend its stringent conditions of entry; but, while insisting on the second language and the mathematics, it did accept other studies than those mentioned. Mr. Lenaghan was absolutely right in stressing the prime importance of English. He disagreed with Sir Victor Shepheard on the alleged lack of science men, but admitted the need for more good school-leavers. They must be taught, too, that a degree conferred no right to a lot more money; it merely showed that the holder had been prepared for a lifetime of learning.

Professor L. C. Burrill suggested that Mr. Taylor-Cook should contribute a supplementary paper on the functions and work of the technical colleges. There should be no difficulty in finding students for additional courses; at Newcastle he had 79 applicants for entry in October, 1957. There was a field for more professorships, but not in Liverpool, where there was no live interest in the subject; Southampton might be a better centre. The shipyards should pay more liberally the men of 28 to 30—the age when they wanted to marry; they might not be worth the extra money immediately, but they were worth keeping, perhaps as assistants to older men or to investigate special problems. Swedish shipyards offered such appointments, but British yards did not.

Dr. S. F. Dorey praised the good work of the technical colleges in connection with the National Certificates; these were particularly valuable because they maintained a continuity of practical work. Shipowners, he thought, should consider the advisability of allowing their engineers leave to take refresher courses. As regards openings, Lloyd's Register did not need a large number of men highly skilled in theory and mathematics; about 5 per cent. was enough.

Mr. T. W. Longmuir, in proposing a vote of thanks to the authors and other speakers, observed that everyone in the meeting depended for his wellbeing on the economical running of ships. That aspect should carry some weight in deciding the nature of the training offered.

JAGUAR'S BACK IN PRODUCTION

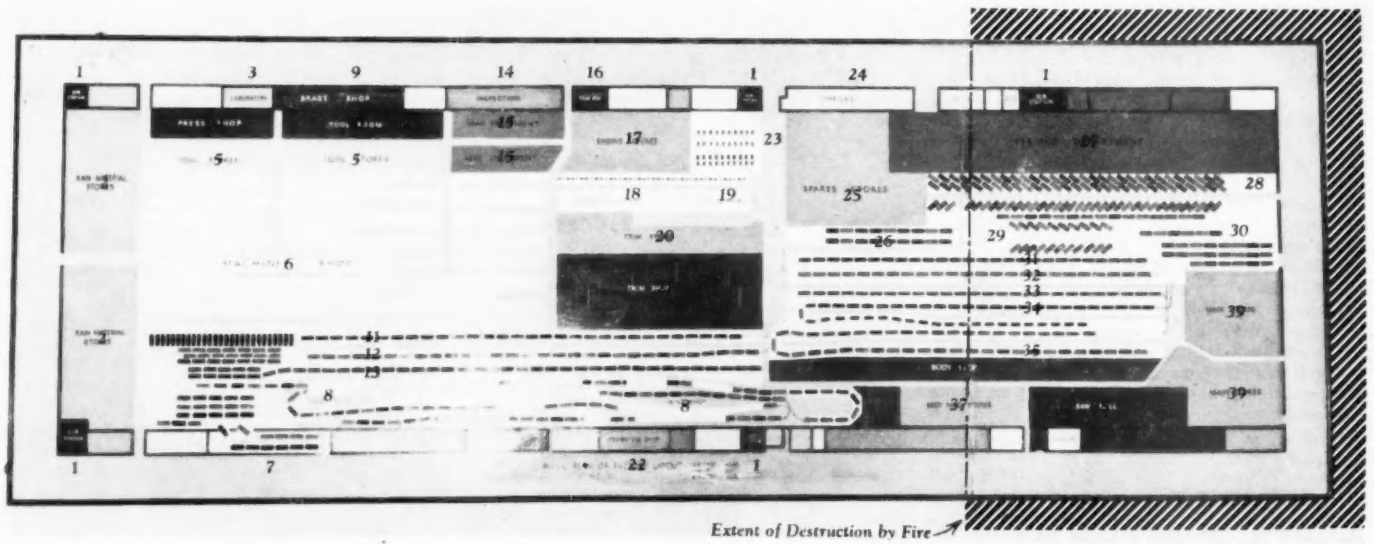
By Gordon Wilkins

The fire on the evening of February 12, which destroyed nearly one-third of the factory of Jaguar Cars Limited at Coventry, and consumed nearly 300 new cars, was a cruel blow at a company which has an unrivalled record of success in export markets. The only unit in the motor industry to have resumed full time working with a full labour force, Jaguar has for long been exporting about 80 per cent. of output, 95 per cent. of its XK sports models going to the United States. Before the fire, production was between 300 and 350 units a week, and was being built up towards the full potential of the factory, which should be capable of producing 500 units a week. National pride in the company's achievements was demonstrated by the front page treatment accorded to the fire in the national daily Press (usually quoting production figures of 1,000 cars a week) and the Queen sent a telegram expressing her sympathy.

The fire seems to have begun in the tyre stores, and spread with startling speed, involving all parts and accessories stores, the saw mill, and spread to the assembly and trim tracks, road test and rectification bays, the delivery department with its lines of new cars, and the service department, where many customers' cars were destroyed. Stores estimated to be worth £750,000 were destroyed and estimates of the total damage run as high as £3 million.

The factory was built on behalf of the Government during the war for armament production, and is leased to Jaguar's. An investigation by Dr. James Firth, director of the North Western Forensic Science Laboratories, has indicated neither arson nor sabotage. The roof is of corrugated iron, lined with a bituminous felt as an insulating material. This seems to have burned very rapidly up above the sprinkler system, and burning debris, falling on stores and cars, spread the conflagration at great speed.

Energetic steps were taken to re-start production. Wrecked cars were dumped on the factory car park, the damaged part of the factory was sealed off, dismantling of the collapsed roof began and the surviving ends of the assembly tracks were joined up to form a shorter dircuit. The day after the fire, the road test and rectification and the service departments had recommenced operations, despite destruction of their installations. At the beginning of the following week, all the 4,000 employees were due to restart work, although some of those in the parts worst affected will have to work alternate weeks of three and 2½ days while reconstruction continues. Production target for the first full week after the fire was 100 cars and full production was expected within three months. Offers of help poured in from other firms in the industry, while the shop stewards on behalf of the trades union members, expressed their appreciation of the management's efforts on behalf of the workers, and pledged full support in speeding the restoration of production.



1. Sub-station
2. Raw material stores
3. Laboratory
4. Press shop
5. Tool stores.
6. Machine shop.
7. Body shell preparation
8. Paint shop.
9. Brass shop
10. Tool room
11. 2·4 litre premount track
12. XK140 and 3½ litre premount track
13. XK140 body finishing track
14. Inspection
15. Heat treatment
16. XK140 trim pen
17. Engine stores
18. Engine sub-assembly
19. Gearbox assembly
20. Trim stores
21. Trim shop
22. Carpenters' shop
23. Engine test
24. Offices
25. Spares stores
26. Finishing track
27. Service department
28. Dispatch
29. Roller test
30. Road test and rectification
31. 2·4 litre trim track
32. Mark VIII trim track
33. XK140 sports trim track
34. 2·4 litre mounting track
35. XK140 and 3½ litre mounting track
36. Body shop
37. Body panel stores
38. Saw mill
39. Main stores.

Layout of Jaguar Works, showing the extent of the damage during the recent fire there. Production has been resumed along the shortened assembly lines.

COMPRESSOR-EXHAUSTER UNITS FOR RESEARCH ON GAS TURBINES

In the October 7, 1955, issue of ENGINEERING *we published a description of the test facilities at the National Gas Turbine Establishment, Pyestock, among which we included the plant house, which provides compressed air and suction supplies to a number of test cubicles used for combustion and aerodynamic research. The main compressor-exhauster plant consists of two Metropolitan-Vickers motor-driven axial-flow compressor sets, which have recently been described in some detail in the Metropolitan-Vickers Gazette, extracts from which are given below.*

Each compressor-exhauster unit (Fig. 1) consists of a 17 stage axial flow compressor running at 7,150 r.p.m., a speed-increasing gear and an 8,850 h.p. driving motor with its exciter, both running at a speed of 1,000 r.p.m.

The driving motor for the compressor is a salient-pole synchronous machine with a directly-coupled overhung exciter. Closed-circuit ventilation is used: the cooling air is passed through water-cooled air coolers which are designed for 180 gallons of cooling water per minute. Thermocouples embedded in the stator windings are connected to a multi-point temperature indicator and this, in turn, is connected to the general alarm system.

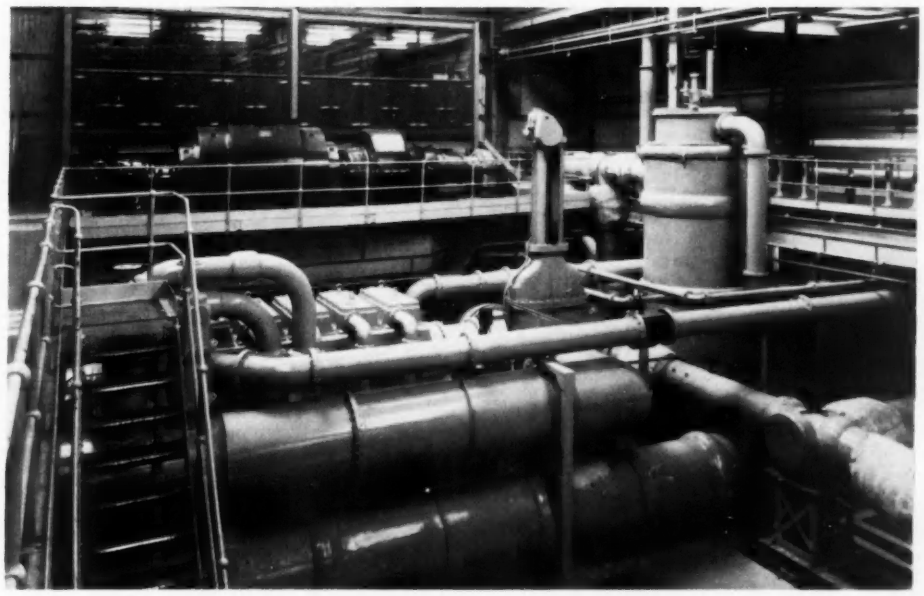


Fig. 1 General view of compressor and equipment.

The compressor-exhauster units are connected to identical independent systems so that one machine can be compressing while the other is exhausting. For certain test purposes, the two systems can be operated in parallel by linking the air bus mains. Fig. 2 shows the complete air system for one unit.

When compressing, filtered air is drawn into the compressor through the air inlet valve *a*. Across this valve is a smaller valve *b* which is used for starting purposes only. After compression, the high-pressure air is directed to the pressure main through valves *c* and *d*, or *e*. Alternatively, if cooler air is required in the mains, a proportion or all of the air may be diverted through valve *f* and the aftercooler before going to valves *d* or *e*.

When exhausting to atmosphere, the machines exhaust the suction mains through valves *g* or *h*, the products of combustion passing through the precooler before entering the machine. The atmospheric exhaust from the machine then passes to atmosphere through the collector box and sound attenuating chambers by way of valves *c* and *j*.

To prevent inadvertent mal-operation causing damage to any part of the system, the air valves are permanently electrically interlocked by a system of limit switches. Valves *g*, *h*, and *a* are interlocked, and valves *d*, *e*, and *j* are similarly interlocked so that only one of each group may be open, and valves *f* and *c* are so interlocked that one must be fully open.

Although the nominal pressure ratio of the machines is 6 to 1, they can be used to give any pressure ratio between 3 to 1 and 7 to 1, the required ratio being maintained by an Askania regulator. This regulator is connected across the compressor, and any deviation from the ratio required operates power cylinders attached to valves *k* and *l* through a hydraulic system. When the unit is acting as a compressor, excess air is passed to atmosphere by the regulating mechanism operating valve *l*: when the unit is exhausting, atmospheric air is admitted to the system, to maintain correct vacuum, by the regulator operating valve *k*.

The air ducting to the compressor inlet is of circular section, 42 in. in diameter; the inlet valves *g*, *h* and *a*, also of 42 in. diameter, are motor-operated wedge sluice valves. The by-pass valve *b* is a motor-operated diaphragm valve. The compressor discharge piping is of 20 in. diameter, and the sluice valves *j*, *d* and *e*, are motor-operated. Valves *f* and *c*, the aftercooler inlet and by-pass valves respectively, are motor-operated butterfly valves.

To allow for expansion of the air pipework, bellows expansion joints are fitted in the various lengths of piping. Some are free bellows which compress to take direct pipe expansions. Others, to take transverse expansion, are linked by two diametrically opposite links, allowing movement in one plane only. Solid and sliding anchors are placed at convenient points in the piping. At the compressor outlet, precautions are taken to ensure that the compressor flanges are not subject to expansion forces set up by the pipe-work.

When discharging to atmosphere either through valve *j* or valve *l*, the air being discharged may contain energy up to the full horse-power of the set. This energy is destroyed by expansion in three stages: in a spoiler box, in a vortex chamber and, finally, in a sound attenuator. The spoiler box is of very rigid construction and solidly fixed to the floor. From the spoiler box, the air passes into the vortex chamber, entering tangentially at the bottom and escaping through holes in a conically-shaped central liner to the sound-attenuating chamber. The vortex chamber is mounted directly over the outlet from valve *j*. The major pressure drop is across the spoiler box and the air passing into the sound attenuator is at such a pressure that the splitter units inside the sound attenuator are not damaged. Fig. 3 shows the spoiler box, the vortex chamber and the lower half of the sound attenuator.

PERFORMANCE

When operating as a compressor with full air inlet at normal atmospheric conditions, each set delivers 60 lb. of air per second at a pressure ratio of 6 to 1 (i.e., discharge 73·5 lb. per sq. in.), and at a temperature of approximately 100 deg. C. through the aftercooler, or at a temperature of approximately 220 deg. C. round the aftercooler by-pass, or, by mixing, at any intermediate temperature. Smaller quantities of air can be obtained by blowing the excess to atmosphere through an anti-surge valve and the discharge system. Lower discharge pressures are obtained by throttling the air inlet valve.

When operating as an exhauster, each set will exhaust to atmosphere 10 lb. of air per second with an inlet pressure of one-sixth atmosphere, or 25 in. of mercury vacuum. Smaller quantities of exhaust from the suction mains can be provided by bleeding air into the system through a "snifting" valve. Spring-loaded relief valves are fitted for emergency protection of the compressors and air system.

LUBRICATION AND COOLING

Each bearing on the set is fitted with two vapour thermometers which are connected to the general alarm and trip protective system. The main oil pump, which is directly driven and has a capacity of 120 gallons per minute, and

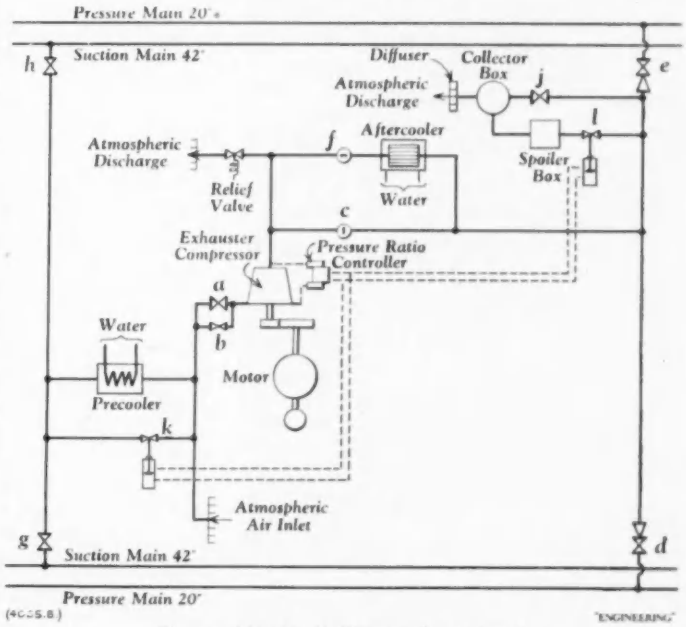


Fig. 2 Air circuit diagram for one set.

an auxiliary pump of 60 gallons per minute capacity are connected in parallel and draw oil from a 600 gallon common oil tank. From the pump, the oil passes through water-cooled oil coolers, and then through a parallel flow system to the bearings and gear sprays. Oil is returned by gravity to the oil tank, where it is strained before being redrawn into the oil pump suction. The auxiliary oil pump is used when starting; when the compressor set is up to half speed, the main directly-driven pump starts delivering oil, and a flow relay in its discharge trips the auxiliary oil pump. When the set is tripped, or if the main oil pump fails in service, the same flow relay automatically restarts the auxiliary oil pump.

The cooling system, like the lubrication system, is a simple closed-circuit parallel-flow system. The cooling water itself is cooled in induced-draught film-type cooling towers. Each unit is equipped with two circulating-water pumps, each capable of delivering 2,850 gallons per minute at a net head of 70 ft. Normally, only one pump is in use, the other being a standby.

On the discharge side of all coolers, with the exception of the air coolers for the motor, water-flow relays are fitted in the pipework. These relays, which measure the water flow, contain contacts connected with starting interlocks. Failure in the water flow through any cooler will cause the relay to operate and shut down the compressor unit.

The precooler, which requires 2,500 gallons of water per minute, is of the cross-flow type, in which air passes horizontally across nests of tubes through which the cooling water flows. To give maximum heat transfer on the air side, the tubes have helical fins.

The aftercooler, which is mounted vertically, is of the shell and tube type. The cooling water flows through the tubes from bottom to top, and the air passes along the outer surface of the tube in the opposite direction. This cooler requires 1,700 gallons of cooling water per minute for full heat transfer. The aftercooler, though not always in use, is at all times subject to the exhaust temperature of the compressor. For safety, a by-pass across the cooler isolating valve ensures a permanent 25 per cent. water flow through the cooler.

To keep the starting load to a minimum, the machines are always started as exhausters. The mains valves *g*, *h*, *d* and *e* are closed, the atmospheric inlet valve *a* is closed, the atmospheric exhaust valve *j* is opened wide, and the small inlet by-pass valve *b* is opened to a pre-determined position. This valve admits sufficient air to allow the compressor to run up to speed without stalling or surging. In this way, the compressor exhausts itself against a minimum back-pressure as it comes up to speed.

The starting sequence of the compressor unit and its auxiliaries is fully automatic. It is initiated by a master control switch mounted on the control desk in the plant control room. Provided that the air valves are in the correct open or closed positions for starting, operation of the control switch starts the auxiliary oil pump. The flow of oil to the bearings and gearbox operates an oil-flow relay which, in turn, starts the circulating water pump supplying cooling water to the oil and air coolers. Water-flow relays in the precooler, after-cooler and oil coolers, close their contacts in series to start the Askania oil pump. This completes the starting of the auxiliaries.

A pressure switch in the lubricating oil circuit energises a time-delay relay which, after a period of two minutes, makes a contact to initiate the automatic starting sequence of the compressor driving motor.

For starting the synchronous driving motor, the auto-transformer method is used. Firstly, a starting contactor closes connecting a starting resistance across the motor field. The transformer neutral contactor and the main contactor are closed in sequence, and the motor starts as an induction motor at reduced voltage.

When the machine has run up to its maximum speed as an induction motor and the exciter voltage has built up, both checked by relays, the starting contactor is opened and the main field circuit breaker is closed, so applying no-load excitation to the motor-field winding, and pulling the machine into synchronism; the neutral contactor then opens and the running contactor closes, applying full voltage to the motor terminals.

Starting and synchronising the driving motor normally takes between 70 and 90 seconds. If, however, the sequence is not completed in a period of two minutes, a timing relay trips to disconnect the motor from the supply.

A series of controls located on a panel mounted adjacent to the set permit non-automatic starting. All interlocks and safety devices are fully operative if, for any reason, non-automatic starting is employed.

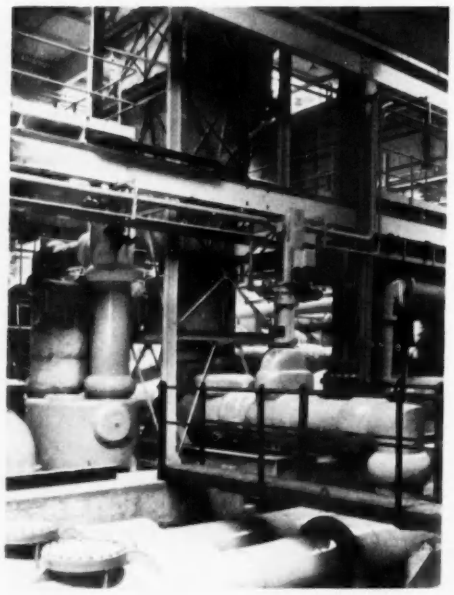


Fig. 3 Air discharge system: air is passed through a spoiler box, a vortex chamber and a sound attenuator.

REFRACTORY STATOR BLADES FOR GAS TURBINES

Since the advent of the jet engine, immense strides have been made in the improvement of metallic alloys, and long-life gas turbines can now be designed to run at temperatures of up to about 1,400 deg. F. (760 deg. C.). This development, however, is probably nearing its limit and in order to achieve a fuel economy comparable with that of a marine Diesel engine, the operating temperature must be raised to something of the order of 2,200 deg. F. (1,200 deg. C.). This will clearly require the cooling of the blades or, alternatively, the use of non-metallic materials. The existence of high centrifugal stresses in rotor blades facilitates cooling by the thermo-siphon principle and at the same time militates against the use of non-metallic materials which tend to be relatively weak in tension. The stator blades, on the other hand, offer a promising field for the application of non-metallic materials and a paper entitled "The Development of Refractory Nozzle Blades for Use in High-Temperature Gas Turbines," presented before the North East Coast Institution of Engineers and Shipbuilders at Newcastle-upon-Tyne, on February 8, described developments carried out in this direction during the last eight years.

The authors of the paper, Dr. T. H. Blakeley, research manager of the Morgan Crucible Company, Limited, London, and Mr. R. F. Darling, who is on the staff of the Pametrada Research Station, Wallsend-on-Tyne, Northumberland, stated that the ceramic materials considered were alumina, zircon (zirconium silicate), silicon carbide, metal-ceramic bodies (sometimes known as "cermets"), carbon, and graphite. These materials were tested in the laboratory under conditions designed to simulate the stresses and thermal shocks encountered in service. Various methods of manufacturing the required blade shapes, by casting or pressing, had also been investigated, and the shapes themselves modified to some extent so as to meet the special requirements of the materials. Cascades of blades had been tested in a high-velocity gas stream at temperatures of up to 2,200 deg. F. Several of the materials tested had been found to have reasonably good resistance to thermal shock, and creep strength at high temperature appeared to be the most serious limitation.

The research had indicated that substances other than alumina were more promising as possible blade materials, and, consequently, work on alumina had been suspended. It had been found that the factor of safety of stator blades made in zircon was low. Metal-ceramic blades held greater possibilities, but there was a nice balance between good creep resistance and good high-temperature strength on the one hand, and good thermal shock resistance on the other.

The materials which seemed likely to fulfil the necessary requirements were the new forms of self-bonded silicon carbide; they were more resistant to oxidation and distortion than the clay-bonded commercial carbides. The former, moreover, combined good thermal conductivity good high-temperature strength, and good creep resistance.

Carbon and graphite, furnished with an impervious coating to prevent oxidation, would be ideal materials, apart from their intrinsic brittleness, but a perfect coating had yet to be developed and it was premature to consider protected-carbon blades at present.

In tests to date the blade-holding pieces had given, if anything, more trouble than the blades themselves, and the prevention of gas leakage was a particularly serious problem which must be solved if progress were to continue. The answer here might be in the use of metallic mountings—possibly protected with a coating of refractory—which could be relatively easily cooled as only a small amount of surface was exposed to the hot gas stream.

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MODERN USES OF NICKEL

Items of particular interest referred to in the current issue of "The Nickel Bulletin," dated December, 1956, and issued by the Mond Nickel Company, Limited, Thames House, Millbank, London, S.W.1, include the nickel electroplating of molybdenum, beryllium, zirconium, germanium and various other "unusual" metals. Developments in the field of nuclear energy have brought new demands on several of these metals and some of these demands can be met only if the metal surface is suitably prepared and protected by electroplating or other similar means. In some cases, one of the difficulties has been to secure good adhesion of the deposited coating or coatings, especially when the metal is heated, and much recent work has been directed to securing high-temperature adherence between two metals of widely different thermal coefficients of expansion.

Progress in the production and use of high-temperature materials is reflected in two abstracts, one relating to the vacuum melting of such materials, and the other to the influence of cold-working on the high-temperature properties of stainless steels. The improvement in properties which can be obtained by vacuum melting, as compared with air melting, of a complex nickel-chromium-iron-molybdenum-titanium alloy is shown by experimental results. As an example of the enhanced properties obtainable, it is reported that the stress-to-rupture of the alloy, for 100 hours at 1,500 deg. F. (815 deg. C.), is 20 per cent. higher for the vacuum-melted alloy

than it is for the comparable air-melted material. With regard to the second abstract, it appears that the beneficial influence of cold-working on the high-temperature properties of 18-8 chromium-nickel steel is now fully confirmed by recent experience.

Another matter of interest concerns the properties and uses of cast iron having a spheroidal or nodular-graphite structure. Allusion is made to certain service records of such articles as furnace doors and frames, petrol-engine crankshafts in farm equipment, pipes for steam-heating coils in oil tankers, glass-bottle moulds, brake bands in large forging presses, the bottom and side plates in coke-quenching cars and spindle housings on surface-grinding machines. The improvements effected, by the introduction of spheroidal-graphite iron in these applications, variously include increased life, more satisfactory service and lowered costs.

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TESTS OF TITANIUM CONDENSER TUBES

Service trials are being conducted at Uskmouth power station, Newport, Monmouthshire, on what are described as the first titanium condenser tubes ever to be installed in a power station in the United Kingdom. The tubes are solid-drawn from I.C.I. titanium 130 supplied by Imperial Chemical Industries Limited. Exhaustive laboratory tests have shown that titanium has a remarkable resistance to many corrosive media, particularly sea water. Now, in co-operation with the Divisional Controller, South Wales Division, Central Electricity Authority, the company are carrying out long-term trials in which a number of titanium tubes is being exposed, under normal service conditions, to a particularly agressive estuarine cooling water to check their corrosion resistance on an industrial scale.

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LARGE STRESS-RELIEVED DURALUMIN PLATES

Controlled stretched Duralumin plates, previously available only from the United States, are now being manufactured in this country by a special process developed by James Booth and Company, Limited, Argyle Street Works, Birmingham, 7. The largest plates recently supplied to a British manufacturer were 25 ft. 4 in. long, 2 ft. 8 in. wide and 2 in. thick. Each plate weighed 1,880 lb., and in spite of their size, had all been subjected to a controlled stretching operation to eliminate the internal stresses occasioned by heat treatment. This operation enables plates to be machined without subsequent distortion.

To ensure that the finished plates are free from internal defects, they are examined by ultrasonic testing methods, first in the as-cast ingot state and later in the finished condition. It is claimed that plates up to 35 ft. in length can be supplied if required, subject to a maximum cross-sectional area of 65 sq. in.

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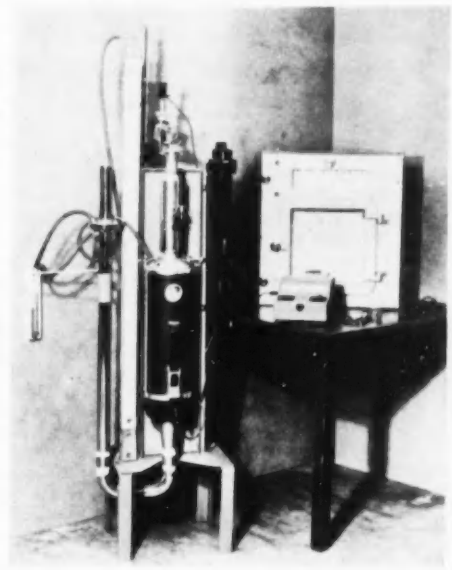
ENGLISH STEEL CORPORATION EXTENSION

The levelling of a portion of the 500 acre site, acquired recently at Tinsley Park, Sheffield, by the English Steel Corporation Limited, has been put in hand. At present the development is confined to an area of six acres in the south-west corner of the site, and on this is to be erected a new works for the manufacture of laminated and coil springs. Actual building operations are scheduled to commence in approximately four months time and to be completed during 1958. The first buildings to be erected will be of fabricated-steel construction, measuring 500 ft. by 300 ft. They will consist of seven bays and will cost about £280,000.

NEW METHOD OF MEASURING DUST IN GASES

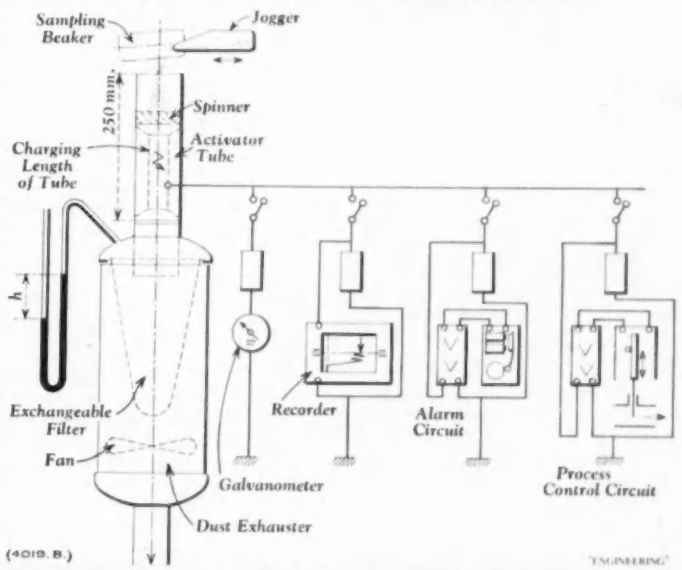
This brief description of a new type of electrostatic dust meter is based on extracts from a translation of an article by Professor Eugen Feifel and Dr. R. Prochaska, "Neues elektrostatisches Staubgehalts-Messgerät," published in Zeitschrift des Vereins Deutscher Ingenieure, *vol.* 97, *No.* 4 (1955).

A new type of recording or controlling electrostatic dust meter, designed primarily as a robust instrument for factory use capable of giving an almost instantaneous response to a change in the dust content of a gas, has been designed and developed by Professor Eugen Feifel of Vienna, who last year was awarded the Gold Medal of the Institution of Austrian Engineers for his work on dust problems. The instrument, which operates on a combination of aerodynamic and electrostatic principles, gives practically a straight-line calibration curve. It can be quickly adapted for drawing off dust samples for evaluation by granulometric, mineralogical or chemical analysis.



In the Feifel electrostatic dust meter, swirling dust particles are charged by contact with the wall of an activating tube which itself becomes oppositely charged. The charge on the tube produces an electric signal on a galvanometer, or other recording means, proportional to the dust content of the gas.

The dust particles to be measured are charged by contact with the wall of a tube selected to give the most favourable electrostatic characteristics. If a dust separator of this type is to reach its highest point of efficiency, it is essential that all, or nearly all of the dust particles should be brought into close contact with the wall of the tube. Referring to the diagram, this is achieved by means of a spinner, upstream of the portion of tube serving as the charging section, which imparts a strong swirl or vortical motion to the axial flow of the dust-laden gas.



In a dust-meter working on this principle, the dust particles leaving the activating tube, each one of which carries a positive or negative charge, can be led into a following tube where they can be made to unload their charge, which can be measured and conducted to earth. A simpler arrangement, however, is obtained by insulating the activating tube itself, and leading the charge on its wall through a galvanometer, this charge being equal in strength and opposite in sign to the charge carried by the particles. A perfect filter (e.g., the measuring beaker or the dust bag), which can be inserted before or after the charging section, serves for gauging, for occasional checking-up, and for removing samples of the dust. In the normal course, the mixture, having by some means or other been relieved of its electrical charge after passing through the activator tube, flows direct to the exhaust fan or ejector and to the point at which the volume of the gas is measured (outlet hole or nozzle). These individual structural elements, and also sampling probes for dust-distribution measurements in closed gas ducts, the arrangements for measuring pressure, temperature and humidity, and any heating arrangements that may be needed, are conventional in design.

The photograph shows a test stand constructed on the principle illustrated in the diagram The dust detector is fitted to an ordinary type of dust extractor, the dust bag or microbe filter of which can serve as a perfect filter. The volume of air handled by the instrument, Q, is regulated by altering the speed of the fan; the maximum value of Q, approximately 10 litres per second, corresponds with a loss of pressure h in the detector of about 600 mm. water gauge. The direct-current, I led from the activator tube can be either measured on a spot-light galvanometer or recorded by an electronic instrument. An electro-magnetic "jogger" gives a means of regulating the strength of the dust supply between the limiting values of approximately 10 mg. per cub. metre and 50 gram per cub. metre; that is to say, the dust strength can be varied within a ratio of 1 to 5,000.

A "dust detector" of this kind, while of simple construction, supplies accurate information and an unequivocal indication of what is taking place. If the instrument is properly designed and constructed, it will provide a regulated perpendicular vortical flow in a downward direction, ensuring the high radial accelerations necessary in order that as many dust particles as possible may come into contact with the wall of the tube in their passage through it. Under ordinary test conditions, for example, using the

dust detector illus[5] trated in the photograph, very high acceleration can be attained corresponding to a speed of about 185,000 r.p.m. in a centrifugal extractor of the same diameter as the activating tube and designed for the same duty.

The electron exchange between the dust particles and the wall of the tube can be the effect either of the particle rebounding from the wall, or of its being torn away from the wall after having made contact with it. The charging of small particles by ion diffusion is determined by their inherent thermal speeds, and thus the charge is proportional to the particle diameter; for larger particles, the motive power of the external electric field is the decisive factor, and results in a charge which is proportional to the square of the particle diameter. Under ordinary conditions, e.g., in the sparking field of the Cottrell filter, the results of both methods of calculation coincide when the particle diameter $= 2\mu$. Thus if the law of granular distribution, i.e., the frequency curve, of a dust fed to the dust detector is known, a comparison of the theoretical maximum value of the total charge of all fractions (assuming, say, a potential difference of 30,000 V per cm.) with the charge corresponding to the measured current I led off from the activating tube, will show whether a substantial proportion of all the dust particles actually did contribute to the " measured magnitude " I. Tests on the new instrument have shown that this fundamental requirement of a reliable dust detector is very largely fulfilled.

MECHANISED PRODUCTION OF INSTRUMENT JEWELS

By R. Humphrey, B.SC.(ENG.), A.M.I.MECH.E.,* *and R. E. Leeds*, M.B.E.*

In an indicating instrument, the method of supporting the moving system is designed to reduce to the lowest possible value any frictional resistance to motion. This is usually achieved by providing, in the axis of rotation of the moving system, one or more highly polished pivots made of hardened steel and engaging in stationary hollowed-out jewels. These jewel bearings, often referred to as V-jewels, are therefore required in large quantities to meet the needs of the instrument industry. They are to-day made from synthetic sapphire which, like natural sapphire, is the single crystal form of α-alumina.

Synthetic sapphire can be grown either in the form of boule (a carrot-shaped piece weighing about 2½ oz.) or rod from 1·5 to 4 mm. in diameter. Both boule and rod are manufactured in substantially the same way, differing little in principle from the original sapphire growing technique conceived by Verneuil in 1902. Essentially, the process[1, 2] consists in feeding finely divided alumina powder through an oxy-hydrogen flame, thus causing it to fuse and subsequently to solidify and build up into a single crystal of sapphire on a refractory support. The length and diameter of these single crystals depend upon the design of the apparatus employed.

A characteristic of boule is that it can readily be split longitudinally into roughly symmetrical " half boules " if tapped lightly on the stem with a hammer. For making jewel " blanks," these half boules are sawn into half-moon shaped slices which are then further sawn into strips and finally into square " blanks." The economic advantage of using sapphire grown in rod form is the elimination of these sawing operations and of the need to convert the squares into discs. Apart from the additional time required for these extra operations, the value of the sapphire lost is considerable.

* Research Laboratories of the General Electric Company, Limited, Wembley, England.

A V-jewel bearing (Fig. 1) consists of a small cylinder of sapphire, one plane face of which bears a conical recess. The apex of this recess has a radius on which the pivot point operates. The point of the pivot is formed to a somewhat smaller radius than that in the bearing jewel. The largest useful V-jewel is 2 mm. and the smallest is 1 mm. in diameter. More than 900 jewels of the latter type are required to cover one penny, and 1 oz. by weight contains over 14,000 of them. All dimensions and limits are specified in British Standard 904 : 1948, and special techniques have been devised to ensure that the V-jewels produced conform to this specification in every respect. The recessed cone is highly polished and the slightest scratch in the radius, visible at a magnification of × 300 is sufficient to ensure that the V-jewel is rejected.

MACHINING SEQUENCES

The sequence of processing operations in making a V-jewel is shown as a flow diagram in Fig. 2. The machines designed for the earlier operations can handle sapphire in either boule or rod form up to the stage at which the " blanks " attain substantially the same shape. This occurs when they are ready for the end-face grinding operation, which brings the discs to the correct thickness.

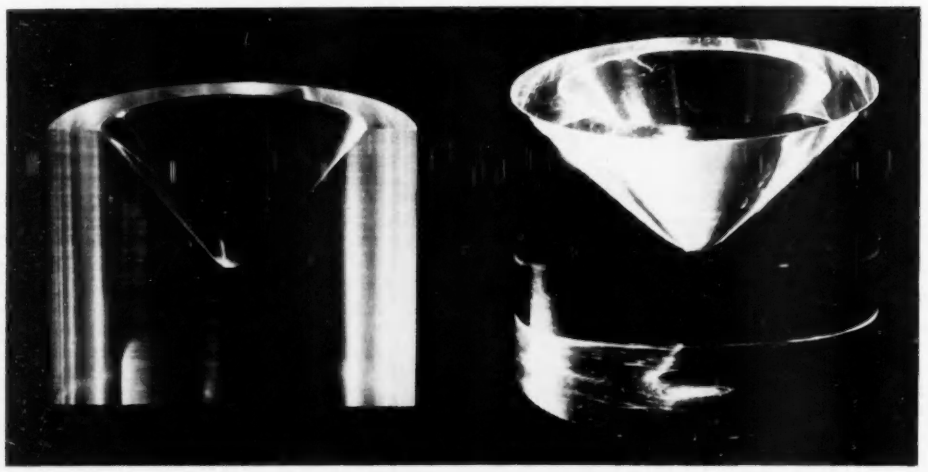


Fig. 1 Enlarged model of V-jewel bearing.

Fig. 2 Flow diagram of sequence of operations in V-jewel manufacture.

Sapphire rod, which has been grown to a diameter about 0·020 in. greater than that of the final jewel, is cut into 4 in. lengths, which are then shellacked side by side on a glass plate and mounted in the sawing machine (Fig. 3). Cutting is accomplished by means of a diamond-loaded phosphor bronze disc, 4 in. in diameter and 0·012 in. thick. The disc is driven at 9,000 r.p.m. by a direct-coupled electric motor running on a 150 cycles per second supply. This direct drive was chosen because of the need for rigidity and freedom from vibration, and the quality of cut is noticeably better than that obtained from machines using belt drives. Poor quality sawing can easily cause incipient cracks in the sapphire which are not detected until the final stages of jewel manufacture.

The workplate carrying the sapphire rods is traversed under the rotating saw disc by means of a pneumatic cylinder working against a hydraulic dashpot which permits speed control to any desired value (Fig. 4). On completion of a cut, the workslide automatically makes a quick return to the starting point. Before making another cut, it is necessary that the saw shall be moved by an amount equal to the required thickness of blank plus the width of saw cut. To do this accurately and consistently without relying on the care of the operator, a stepping motion[4] was devised. The saw saddle is in two parts, each of which can be clamped pneumatically to the bed of the machine. By clamping and unclamping the two parts in sequence, the saddles being subject to a constant force along the bed of the machine, the whole arrangement can be made to step along the bed by an amount determined by the setting of the stop-nut. This amount can be varied from zero to about 10 mm. The valve operating sequence is obtained by a single turn of a handwheel.

Sawing requires a copious supply of soluble oil coolant. Coolant pipes either side of the diamond-loaded disc are mounted on the cast aluminium splash guard.

As already mentioned, three separate sawing operations are necessary in cutting sapphire boule (Fig. 5). First the half-boules are sliced transversely into " half-moons," then the half-moons are cut into square-section rods and finally the rods are cross-cut into cubes.

To prepare them for grinding several hundred sawn blanks are stuck with shellac on to a glass

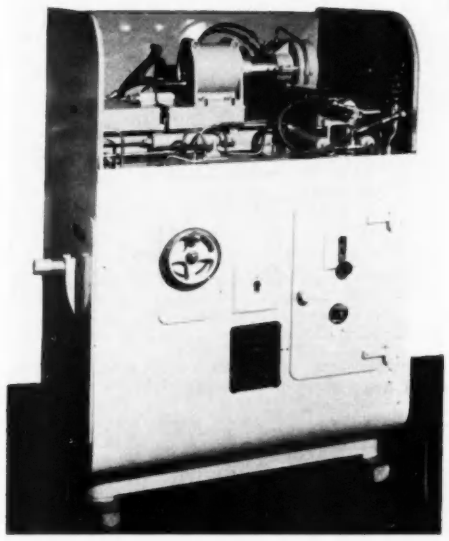


Fig. 3 Overall view of sawing machine.

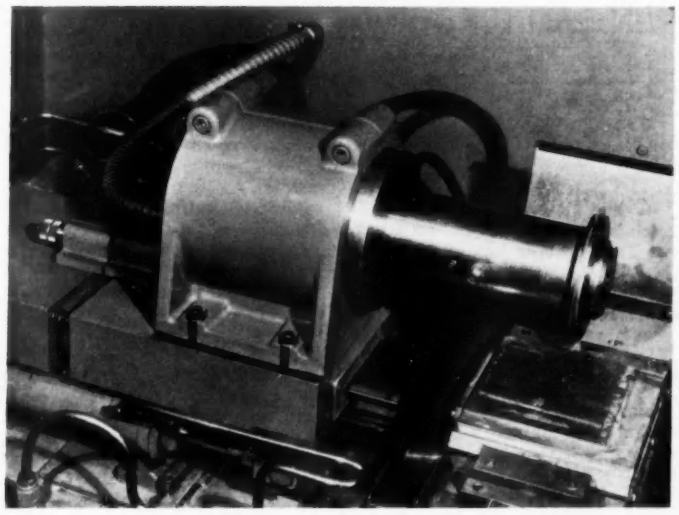


Fig. 4 Close-up of work-table of the sawing machine. Behind the head are the two stops which control the thickness of the jewel blanks.

plate. The plate is caused to reciprocate across a rotating cast iron lap which is fed with a small quantity of diamond powder. When flat smooth surfaces have been obtained, the blanks are reversed and lapping repeated until the correct thickness is obtained.

The blanks are then arranged end-to-end on the work rest of the machine, and a rubber-faced control wheel drives them against the diamond-loaded copper cutting wheel which rotates at 3,000 r.p.m. Accurate diameters can be obtained by feeding in the control wheel to a pre-determined position. It takes about 60 seconds to grind 90 circular blanks cut from rod.

Square section blanks cut from boule require a two-stage treatment. Firstly, a rough grinding operation to remove the corners, which calls for a machine running as an " up-grinder " (Fig. 6). Secondly, because a machine running in this fashion will handle the squares satisfactorily but does not generate true circles, the blanks must be finished on a machine running as a " down-grinder."

The machine described here is a dual-purpose machine for either " up-grinding " or " down-grinding." The copper cutting wheel can be re-loaded with diamond powder without removing it from the machine, by means of a steel roller attachment which can be mounted in place of the splash cover. The cutting wheel is driven at 100 r.p.m. for this operation.

In the recessing operation a conical cavity is made in the jewel. A hard steel needle, the point of which is ground to the same angle as the required conical cavity, is used in conjunction with loose diamond powder in a water-gelatine solution. The needle rotates at high speed, and at the same time oscillates axially. This combined rotary and oscillatory action causes the diamond particles to chisel into the sapphire. The needle point wears quickly under these conditions, and must be restored by regrinding at frequent intervals.

The recessing machine[3] has been designed to perform these functions automatically (Fig. 7). It is, in fact, fully automatic, and once loaded with blanks, can be left unattended. A camshaft rotating at 2 r.p.m. controls the needle-grinding operation which is repeated every 30 seconds. The needle spindle and needle-grinding wheel are belt-driven from a countershaft. The jewel blanks are mounted in cylindrical holders, the top parts of which form cups to hold the diamond powder. These holders are loaded into the machine, as shown in Fig. 8, being held in slots in an endless belt of thin stainless steel. The holder in the working position is located by means of a vertical V-block. Fig. 9 shows diagrammatically the sequence of events during the recessing of a jewel. Needle oscillation is achieved by means of a solenoid coil around the spindle, the coil being fed from an interrupted direct-current supply.

Amplitude of oscillation is closely related to rate of penetration. Too great an amplitude, however, will lead to cracking of jewels and also to badly shaped cavities because of excessive needle point wear. Breakage is less likely, and shape less important, during the early stage of recessing, so it is advantageous to have a variable amplitude, commencing at about 0·020 in. and diminishing progressively as the recess deepens. This control is conveniently obtained by means of a uni-selector which is made to advance one step after every grind cycle, and to bring an extra unit of resistance into series with the oscillator coil.

Recessing rates tend to vary slightly, probably because of differences in the qualities of the sapphire and the diamond powder. It is necessary, therefore, to have a means of stopping the recessing of a jewel, and starting another one, only when the correct recess depth has been reached. This is done by having electrical contacts in the needle spindle head. These are arranged as shown in Fig. 10. The contacts are separated when the needle first makes contact with the jewel blank, the spindle being deflected upwards against its spring. As the recess becomes deeper, the contacts approach one another and touch when the correct depth has been reached. The closing of the contacts operates a relay which in turn does two things—firstly, it breaks the oscillator circuit and prevents further recessing. Secondly, it operates a solenoid which permits indexing of the jewel carrier belt during the next grinding cycle.

The V-block which holds the cylindrical jewel holders during recessing is provided with lever and screw adjustment. This enables the block to be set accurately in two directions, so as to make it coaxial with the recessing needle. This feature is important because of the need for making the recess concentric with the periphery of the jewel.

Brush polishing and chamfering follows; this operation removes all sharp edges of the jewel and polishes the end faces. The jewels (about 1,000 at a time) are shellacked by their end faces to a cast-iron disc which is mounted in the machine and rotated against a revolving brush, the bristles of which are impregnated with a mixture of oil and fine diamond powder. After about 10 minutes of this treatment, the jewels are removed and reversed and the process repeated for the other end.

RECESS POLISHING

The final and most exacting operation of the series is to obtain an exceedingly high polish, without scratches, in the lower part of the recess, and at the same time to maintain the correct recess shape, with the necessary small radius of curvature at the bottom.

The operation is in some respects similar to recessing in that conical-pointed needles are used, the needle rotating at high speed and oscillating axially. The effect of the oscillation however is not one of impact, but of sliding, since the needle is loaded radially, as well as axially, against the jewel. The jewel also rotates at a lower speed, and in a direction opposite to that of the needle.

Fig. 11 shows a two-head polishing unit. The needle carriers can readily be removed from the machine for repointing, which is done elsewhere to avoid dispersing grit particles which would cause scratching of the polished surface. A sequence of two steel needles and one boxwood needle is used, the points being dipped in pastes

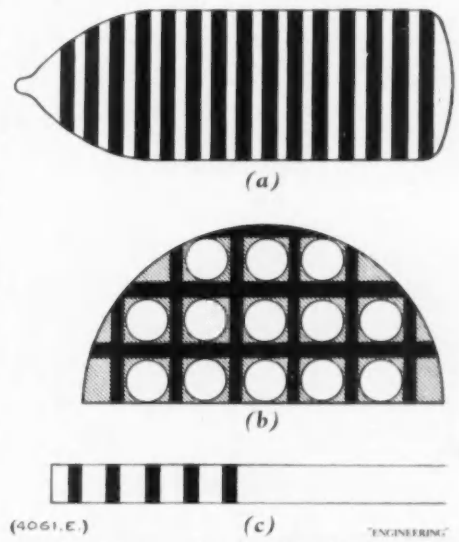


Fig. 5 Diagram showing how jewel blanks are cut from half boules and rod. (a) Normal boule; (b) cutting jewel blanks from boule 3 mm. squares; (c) cutting jewel blanks from rod (shaded areas represent waste).

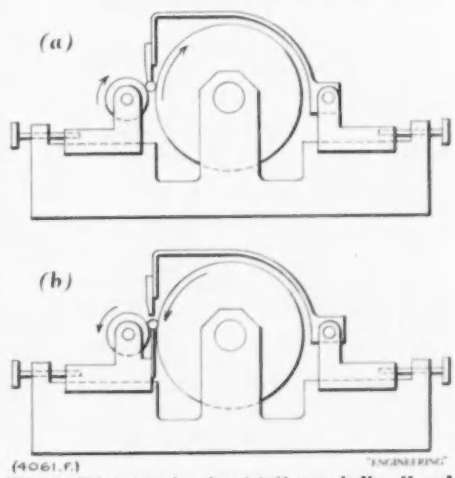


Fig. 6 Diagram showing (a) " up-grinding " and (b) " down-grinding."

made of diamond powder of progressively increasing fineness. Four minutes' polishing with each of the three needles is allowed per jewel.

TESTING

Assessing the quality of the product produced by the machines at each stage of the sequence involves a considerable amount of testing. Rough surfaced sapphire is most abrasive, and special precautions have to be taken to avoid excessive wear of the apparatus used. For example, the simple operation of measuring the diameter and thickness of sapphire discs with a micrometer was unreliable through rapid wear of the micrometer jaws until these were tipped with a cemented tungsten carbide.

Three of the most important characteristics of a finished V-jewel are the radius of curvature of the apex, the eccentricity of the recess with respect to the jewel axis, and the degree of surface finish achieved by the polishing process. By fitting specially designed holders to metallurgical type microscopes, all three tests could be carried out in one operation. Cleaning the jewels to a standard satisfactory for assessing the surface finish in the apex of the recess was a major problem until finally a jet of steam was used for this purpose.

A special projector was built to measure rapidly the included angle of the recessed cone; to eliminate the optical effect of the cylindrical shape of the V-jewels, they are immersed in a bath of methylene iodide which has practically the same refractive index as that of sapphire.

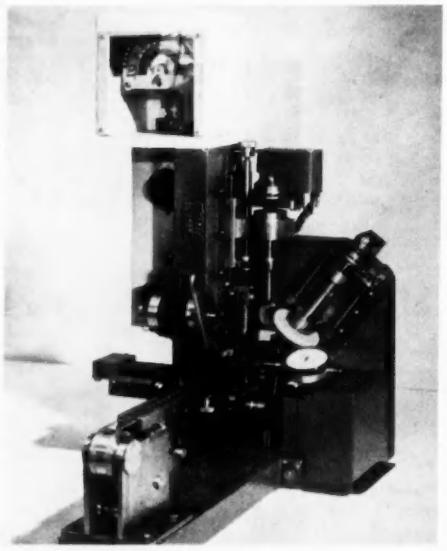
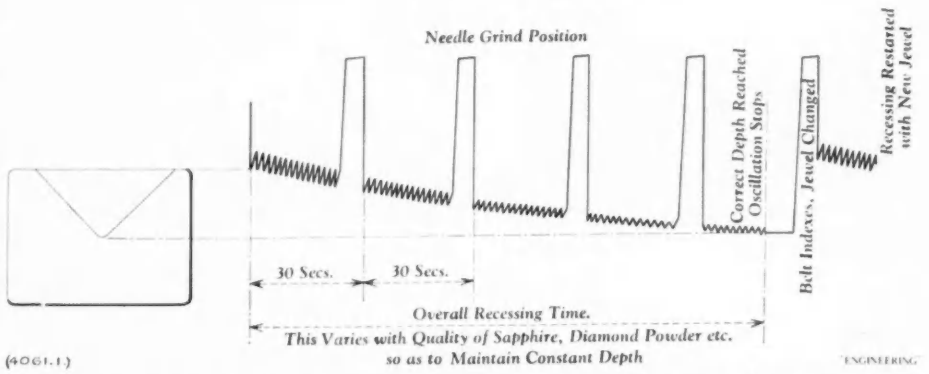


Fig. 7 Overall view of recessing machine. The needle is re-ground every 30 seconds.


Needle Grind Position
Correct Depth Reached Oscillation Stops
Belt Indexes, Jewel Changed
Recessing Restarted with New Jewel
30 Secs.
30 Secs.
Overall Recessing Time.
This Varies with Quality of Sapphire, Diamond Powder etc. so as to Maintain Constant Depth
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ENGINEERING

Fig. 9 Diagram showing movement of needle point during recessing of a jewel. Note that amplitude of oscillation is automatically reduced after every grind cycle.

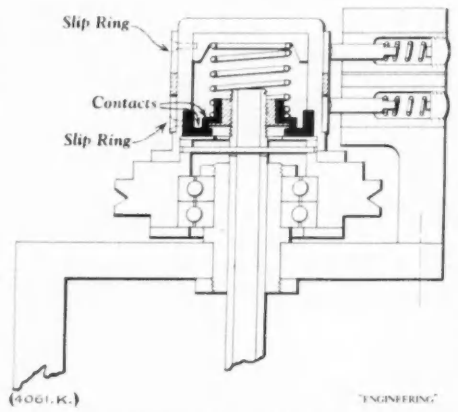

Fig. 10 Arrangement of switch in needle spindle head of recessing machine. This governs the depth of the recess cut in the jewel. The contacts are separated when the needle touches the blank and make again at the required depth.

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[1] Brown, K. W., Chirnside, R. C., Dauncey, L. A., and Rooksby, H. P., "Synthetic Sapphires," *G.E.C. Journal*, Vol. XIII, No. 2 (August, 1944).
[2] Chirnside, R. C., "Synthetic Sapphire in Rod Form," *Electrical Industries* (August, 1950).
[3] British Patent Appln. No. 16086/54.
[4] British Patent Appln. No. 16087/54.

SEMI-RESILENT SUSPENSION FOR TRACTION MOTORS

Controversy over the causes of increased deterioration of railway track led the Southern Region to conduct a detailed investigation into the behaviour of the track under different loading conditions. In addition it was found that the equipment, developed with the co-operation of Savage and Parsons Limited, Watford, Hertfordshire, was also of value in determining the stresses occuring in bogie structures.

The technique adopted was to use resistance strain gauges in conjunction with direct-current amplifiers and oscilloscopes equipped with cameras for taking continuous records. The equipment was used to compare the bending stresses set up in bull head-and flat-bottom rails by various types of rail vehicles. Particular attention was paid to the comparative performances of nose-suspended and resilient-suspended electric motors in multiple unit stock. Measurements were also made, using quartz accelerometers, of the accelerations imposed on axle boxes, bogie frames and traction motors by the passage of the vehicle along the track.

In the light of the results of these tests, a form of traction-motor suspension has been developed for multiple-unit electric stock which gives a degree of resilient support of the motor without the complexity of a fully resilient motor. The arrangement makes use of lightweight motors and spring-mounted gear wheels, the support of the motors being achieved by interposing annular rubber rings between a roller-bearing suspension tube which surrounds the axle and the motor frame. A bogie including two motors with this form of drive has been built and is undergoing service trials.

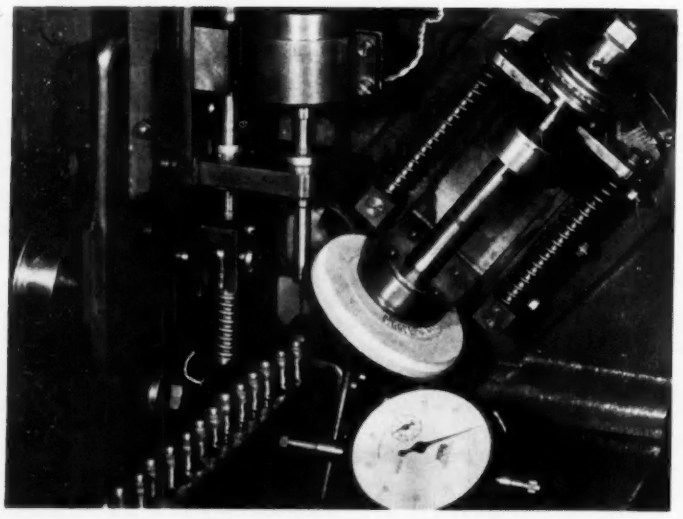

Fig. 8 Close-up view of recessing machine. The jewels are carried in the cups which retain the diamond powder.

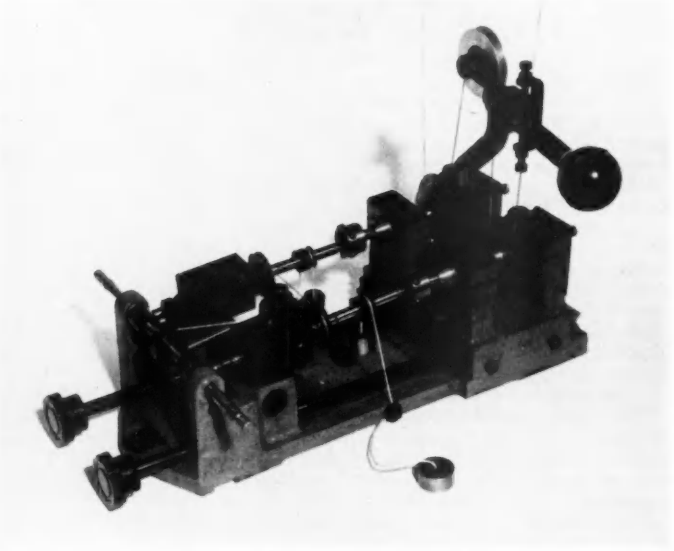

Fig. 11 Close-up of two-head cone polishing machine. Two steel needles and one boxwood one are used in sequence.

THE COMPANY OF DISABLED WORKERS

SOLVING OTHER FIRMS' PRODUCTION WORRIES

Shortage of factory space, of labour, or of skilled management—and sometimes of all three—have long been limiting factors in industrial expansion. At the same time, Remploy, Limited, the national organisation employing 6,000 severely disabled men and women, operates at a loss of about £2,500,000 a year, this sum being made good by the Treasury. Remploy, Limited, have 90 factories, in various parts of the country, all coming under the control of their head office at 25-28 Buckingham Gate, London, S.W.1.

These are the facts on which Mr. S. Green, managing director of Remploy, based his sponsorship scheme, which is designed to assist both his own organisation and industry in general. Briefly, the idea is that an industrial company, wishing to expand its production, undertakes to re-equip a Remploy factory with the appropriate machinery, provide the necessary technical knowledge, supply raw materials, and buy back the finished products at an agreed price. The sponsor firm guarantees orders over a considerable period. Once the necessary plant has been installed and the disabled workers have been taught to use it, Remploy take over the full responsibility for production at the agreed rate of output, and the sponsor firm does nothing but supply raw materials and dispose of the finished products.

Such a plan had much to commend it right from the start, but it remained to be seen how it would work out in practice. Three sponsorship schemes are now in operation, one having been in production for 12 months, while the other two have worked for shorter periods. One of the three schemes has no connection with the engineering industry, but the original one is for the production of engineering components, and the sponsors have been so satisfied with the success of this scheme that they have entered into a second agreement, this time for engineering repair work.

The oldest of the sponsorship schemes is operated on behalf of Dowty Seals, Limited, Cheltenham, and provides employment for an average of 50 to 60 disabled persons, all tubercular cases, in a Remploy factory at Bristol. Production was at first solely of " O " rings, but metal and rubber bonded seals are now produced as well, and the present range of products is: " O " rings from $1\frac{1}{8}$ in. inside diameter to $\frac{1}{4}$ in., and bonded seals from $1\frac{5}{16}$ in. to $\frac{33}{32}$ in. The change of production was achieved without difficulty, the scheme proving flexible, as it was intended to be.

The Bristol factory was originally devoted to woodworking and, as the old machines were moved out, so the Dowty machines were installed by Dowty fitters, the necessary technical supervision also being supplied by the sponsor firm. Small groups of Remploy workers were transferred to the new plant as soon as any of it was ready, so that training proceeded while the rest of the equipment was being installed, and a gradual change-over from one type of product to another was achieved.

At present, there are three production lines, each headed by an injection moulding machine. Space is available for a fourth line, which it is proposed to install. Multiple moulds are used for the production of " O " rings, and as they come from the press they pass to an electric oven for curing the rubber. The moulds are then stripped to remove the moulded seals, re-assembled, and sent back along a chute to the moulding machine. Seals are barrelled with steel balls at a low temperature (produced by dry ice), to clean off the flashes, and then trimmed on both the internal and external diameter by means of revolving abrasive stones. They then pass to inspection, which is on a 100 per cent. basis, and are colour-spotted for identification before packing. The factory is approved by the Aeronautical Inspection Directorate, and the products are made and inspected to A.I.D. standards.

Production of bonded seals is carried out in the same injection moulding machines, with multiple moulds, but the production procedure is naturally somewhat different from that used for " O " rings. Steel rings, already cadmium plated, are supplied, like the rubber for both types of product, by the sponsor firm. The rings are de-greased with trichlorethylene, and a bonding agent is applied to the inside diameter. Assembling into moulds follows, and the moulds then pass to the injection moulding machine, where the rubber is bonded into position and moulded to size and shape. After curing in the electric oven the moulds are broken open and the seals are extracted. Re-assembled moulds, with a fresh set of rings in position, go back to the moulding machine, and the seals pass to a specially-designed machine which punches the flash out. As they leave this machine the seals are inspected on a conveyor belt, the inspection again being 100 per cent., and finally they go to the packing room.

It is sometimes a matter for comment by visitors that the workers in the Bristol factory do not appear to be disabled in any way. That is true, for the factory concentrates on the employment of tubercular cases, who have disabilities which are not obvious to a casual observer. Nevertheless, it often happens that they are unable to work in a normal way. Heavy physical effort, for example, cannot be permitted, and while the processes carried out normally lend themselves to easy, seated operation, a few special arrangements have had to be made. For instance, it has been necessary to provide power-driven equipment for opening moulds after they have passed through the curing oven. Frequently, too, a worker may only be able to do a few hours work each day, and provision has to be made for this in production planning. The factory personnel often changes, also, as workers with less serious disabilities become fit and are medically discharged, when they leave and seek work in outside industry. This may well mean that the factory loses its best workers from time to time, and production must continue in spite of such changes.

These and many other problems have to be overcome in running a factory of this type, and the Remploy management are fully prepared for them. Problems are solved and production goes on, the sponsor being relieved of all responsibility for the day-to-day running of the factory. The sponsorship scheme has proved that a factory which is run primarily for employing persons who could not work elsewhere because of their disabilities, can nevertheless provide a useful service to industry. Development continues, and the idea is not confined to the manufacture of small, light articles. The second of the engineering sponsorship schemes is for the repair and maintenance of hydraulic pit props, for which handling equipment is necessary in any case.

BETTER TRAINING FOR FUTURE ENGINEERS

Imagination and Communication

Taken together, speeches at three recent functions give a general outline of the future requirements for engineers. Said Sir Hugh Beaver at the annual dinner of the Institute of Refrigeration, " The engineer is the largest single source of top level management." He then proceeded to develop the necessity for early training and the same view was taken later in the evening by Lord Dudley Gordon, President of the Institute, and by Mr. A. O'B. Brandon, a member of Council, who said that the split of engineers into specialists was largely inevitable in modern industry, but it was a tendency that should be counteracted by endeavouring to widen the outlook of each. This could be done by developing imagination in both graduates and students, and seeing that only fundamentals were learnt at college, so that later in the works they could learn their specialist trade, and not be drowned in a sea of detail.

It should never be forgotten that engineering is an art as well as a science, and many of the great ones of the past relied largely on intuition. Clear mind and detached thinking are necessary, but the imagination must play its full part.

The need for imagination was also stressed by Sir Walter Puckey, speaking to the students of the Brighton Technical College at the annual distribution of prizes and awards. He warned most of those present that they would live to see the factory of 1984, whether under the supervision of " Big Brother " or not. They should not forget that, as Kipling said, machines " are nothing but the children of your brain," and that human imagination must, therefore, play its part in understanding human needs. People spoke of the second industrial revolution that was now taking place, but the horrors of the " dark satanic mills " of the first must never again be allowed to darken human lives. Imagination and knowledge would have to go hand in hand to produce the world of the future. The need now was for more skilled engineers and technicians who would be capable of designing and maintaining the rather complex machinery necessarily involved in the factory of the future, which would be largely automatic.

Government training schemes, said Mr. Harmar Nicholls, Parliamentary Secretary to the Ministry of Works, when speaking at the annual dinner of the Institution of Heating and Ventilating Engineers, would assist towards the training required for engineers of the next generation. The most must be made of these training schemes to enable this country to hold its own in the markets of the world. One of the important things was to let people know what was going on in the fields of research, so that the best results could be obtained by the quick developments to practical use of the many important discoveries and developments now being made. He appealed for a better use of materials, skills and research. The President of the Institution, Mr. J. Clifford Byles, endorsed the need for communication of research facts and also for inter-change of knowledge between specialists both in their own fields and in the field of general engineering. This could be done by papers and discussion.

What points arise from these speeches? Probably that the greatest need of engineers of the future is a strictly basic training in the principles of the field of general engineering, followed by a specialist study in their own branch, always accompanied by a free exchange of information, so that no discovery in any one field be left to languish unknown, but is utilised to its greatest advantages wherever it may be applied.

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RADIO FOR SHUNTING

To speed up shunting operations in the Eastern Region's marshalling yard at Wath, two-way V.H.F. radio equipment has been installed. Telephone communication is now possible between either of the two hump-point signal boxes in the yard and each of five locomotives. The channel spacing is 100 kc/s and the power used is 5 watts. The equipment was supplied by Marconi's Wireless Telegraph Company, Limited, Chelmsford, Essex.

Book Reviews

SCOPE OF ATOMIC ENERGY

WORLD VIEW

Peaceful Uses of Atomic Energy: Proceedings of the International Conference in Geneva, August, 1955. Vols. 1–16. *H.M. Stationery Office, Kingsway, London, W.C.2.**

Probably the most comprehensive assembly of nuclear data so far published is that contained in the *Proceedings of the International Conference on the Peaceful Uses of Atomic Energy*, all 16 volumes of which are now available. Although well over a year has passed since the Conference took place in Geneva, the wealth of information released on that occasion has yet to be fully assimilated, and there can be little doubt that these volumes will remain the major published source of atomic knowledge until a second conference is held. Indeed, many of the articles on nuclear subjects still appearing in technical journals are based largely on Geneva Conference papers. It is probable that future conferences will be of a specialist nature, or limited at least to a given range of subjects; these *Proceedings*, which cover almost every aspect of atomic energy, are therefore likely to remain unique.

* Volumes obtainable separately as follows: Vol. 1: The World's Requirements for Energy; The Role of Nuclear Power (57s.). Vol. 2: Physics; Research Reactors (57s.). Vol. 3: Power Reactors (54s.). Vol. 4: Cross Sections Important to Reactor Design (54s.). Vol. 5: Physics of Reactor Design (63s.) Vol. 6: Geology of Uranium and Thorium (63s.). Vol. 7: Nuclear Chemistry and the Effects of Irradiation (70s.). Vol. 8: Production Technology of the Materials Used for Nuclear Energy (70s.). Vol. 9: Reactor Technology and Chemical Processing (70s.). Vol. 10: Radioactive Isotopes and Nuclear Radiations in Medicine (57s.). Vol. 11: Biological Effects of Radiation (57s.) Vol. 12: Radioactive Isotopes and Ionizing Radiations in Agriculture, Physiology, and Biochemistry (63s.) Vol. 13: Legal, Administrative, Health and Safety Aspects of Large-Scale Use of Nuclear Energy (50s.) Vol. 14: General Aspects of the Use of Radioactive Isotopes; Dosimetry (45s.) Vol. 15: Applications of Radioactive Isotopes and Fission Products in Research and Industry (54s.). Vol. 16: Record of the Conference (36s.).

Energy Supply and Demand

Volumes which have recently appeared include one devoted to future world energy requirements and the part nuclear power will play in helping to meet them (Vol. 1). Among the topics covered are power needs over the next 50 years, the influence of economic factors, the supply and demand of energy in some 30 countries, the capital investment necessary for the development of nuclear power, problems of international co-operation, and education and training. A great deal of tabulated data is provided, and apart from general surveys, there are papers concerned, for example, with the role of thorium in the application of nuclear energy, the use of plutonium (a particularly interesting paper in view of its probable value in advanced reactors), and the need for small and medium nuclear power plants. Present sources and distribution of energy are especially well analysed; it appears, for instance, that less heat is used domestically than industrially but considerably more is wasted (Fig. 1); and that there is an approximately linear relation between a country's energy consumption and its income (Fig. 2).

Power and Research Reactors

Reactors for research and power production are discussed in Volumes 2 and 3, references to which have already been made in ENGINEERING (vol. 181, pages 337 and 370, 1956). Volume 2 opens with a number of papers on special topics in nuclear physics, such as neutron scattering and radioactive decay, but is mainly devoted to descriptions of research reactors, operating or planned, including DIDO (Fig. 3), BEPO, MTR, ANL, ORNL, SUPO, the Soviet RPT, the Norwegian JEEP and others. Apart from a consideration of fuel cycles and fuel economy,

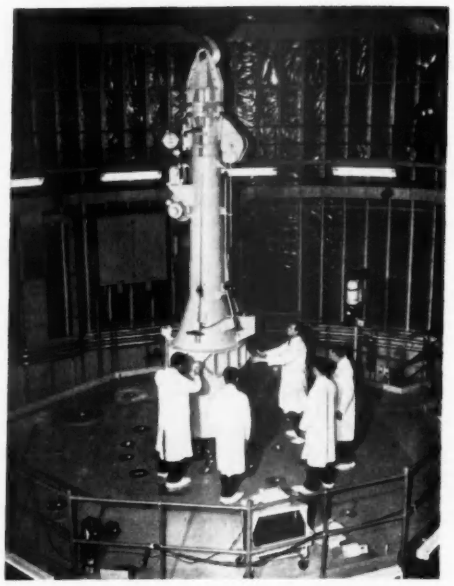


Fig. 3 Fuel-element loading and unloading flask being placed in position over the high-flux materials-testing reactor DIDO. Though only recently completed, DIDO was described in detail at the Geneva Atomic Energy Conference.

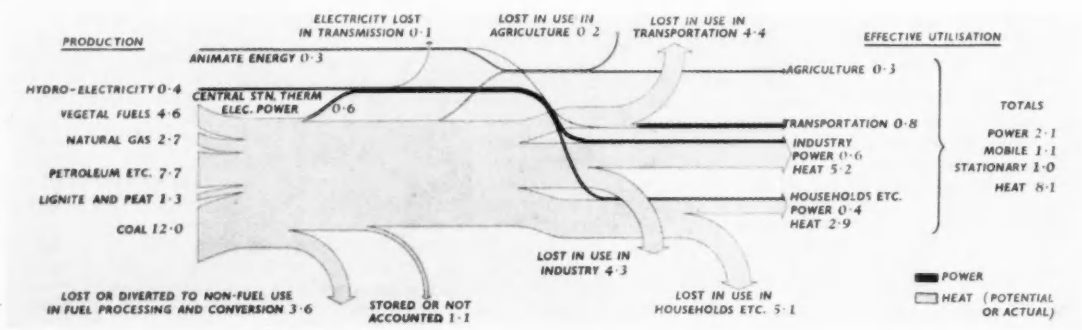


Fig. 1 Origins and use of the world's energy resources before the atomic age: sources of supply and distribution in 1952.

Fig. 4 (below) Reactor vessel for liquid-metal-fuel reactor, using a uranium 233-bismuth fuel and a thorium-bismuth blanket. Since the fuel is fluid, it may be continuously processed.

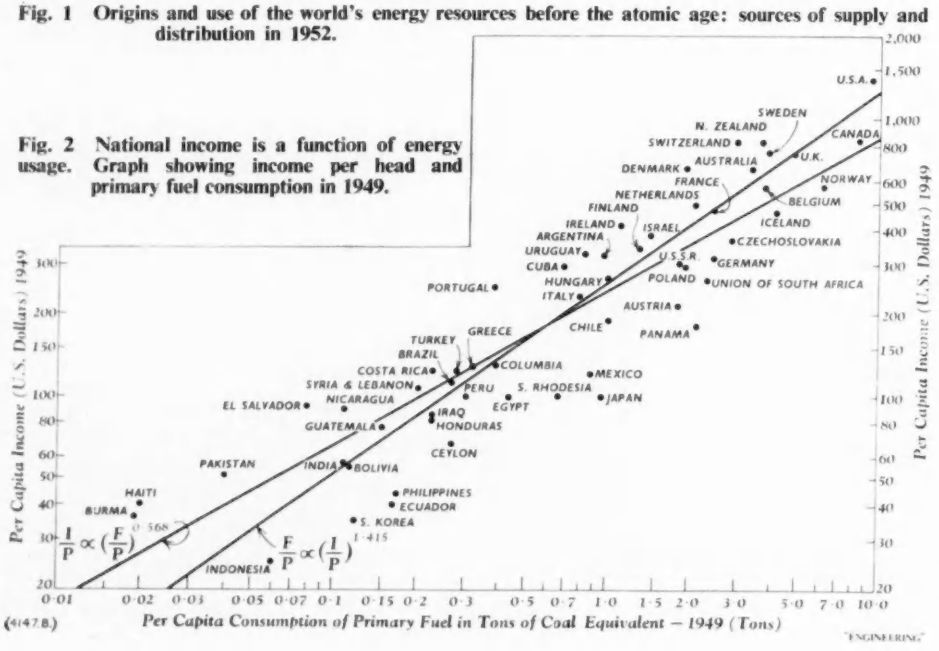
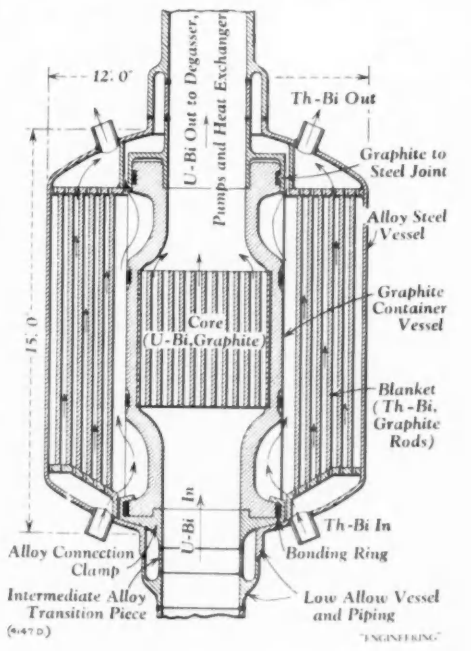


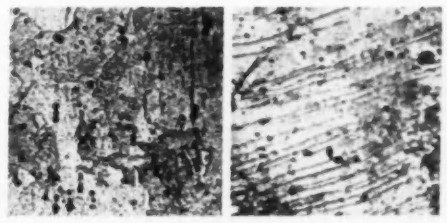
Fig. 2 National income is a function of energy usage. Graph showing income per head and primary fuel consumption in 1949.



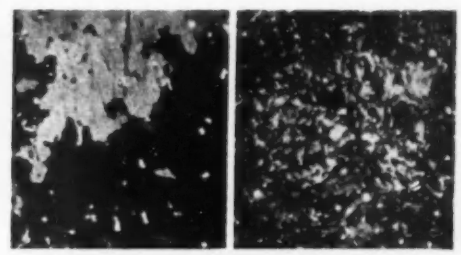
Volume 3 is mainly concerned with specific power reactor projects, and is particularly interesting in its references to such advanced systems as the liquid-metal-fuel reactor (Fig. 4), homogeneous and heterogeneous reactors fuelled with dry suspensions of uranium oxide, fast breeder reactors (Fig. 5), sodium-graphite reactors and various forms of water-cooled and moderated reactors including boiling designs. Many of these papers have been summarised in ENGINEERING, the bulk in vol. 180, 1955.

Reactor Physics

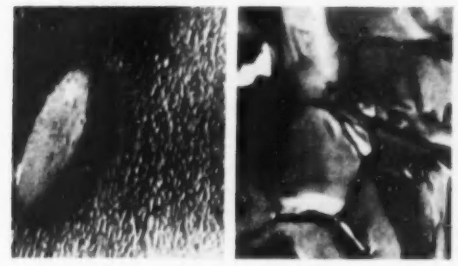
Volumes 4 and 5 are concerned with reactor physics, the first with cross-sections, the second more generally with the use of physics in reactor design. The operation of a nuclear reactor depends ultimately on the neutron cross-sections of all the materials it embodies, since they are a measure of the use or wastage of the free neutrons necessary to maintain a chain reaction. A cross-section may be understood figuratively as the area presented by one particle to another, as when a free neutron collides with an atomic nucleus in some solid material; the larger the area the greater the chance of capture. Actually, of course, the " area " of both particles must be taken into consideration. In other words, the cross-section for a reaction between two particles is a measure of the probability that the reaction will occur under given conditions, and does of course depend on the speed of the incident particle. Volume 4 provides a broad and detailed survey of techniques and instruments used in the investigation of particle behaviour, dealing with selectors (Fig. 6), pulsed sources, time-of-flight measurements, spectrometry and accelerators. The cross-sections of various materials are given; and such related topics as delayed neutrons, capture, fission and resonance are discussed. These ideas are amplified in Volume 5, in which the qualities of various moderators are examined, together with such subjects as criticality, critical assemblies, variations in reactivity and lattice calculations. Several zero-energy thermal and fast reactor studies; and a number of exponential experiments are described, and there are treatments of reactor kinetics and general reactor theory.



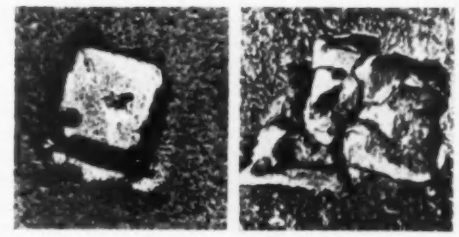
(*a*) Uranium metal (× 240).



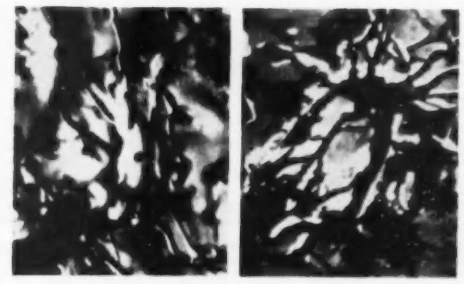
(*b*) Beta quenched uranium (polarised light, × 50).



(*c*) Uranium metal (× 7,500).

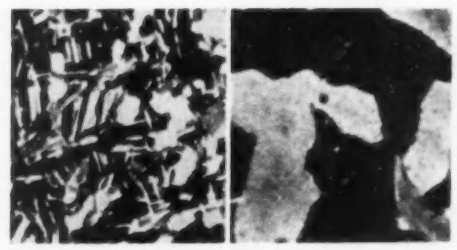


(*d*) Uranium carbide grain (× 2,250).



(*e*) Uranium carbide grain (× 7,500).

(*f*) Copper.



(*g* Zirconium.

Fig. 7. Various materials before (left) and after (right) irradiation, showing the effect on grain size and micro-structure generally.

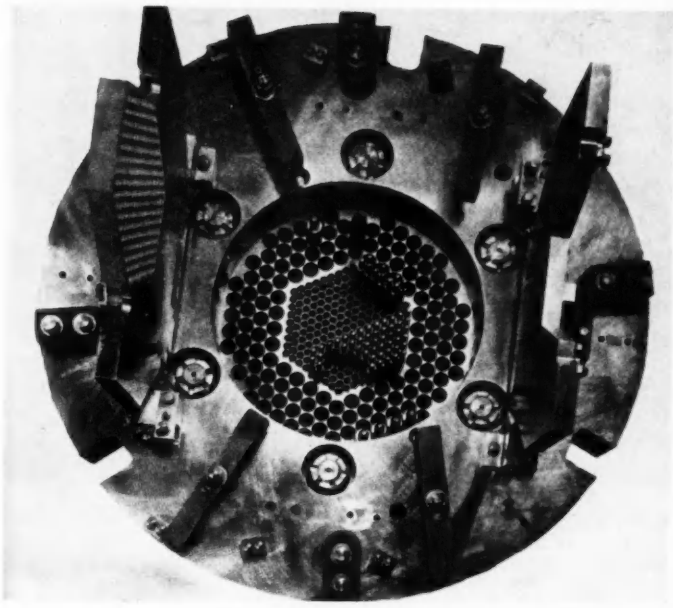


Fig. 5 Top of experimental sodium-potassium cooled fast breeder reactor (EBR), showing some fuel elements (inner hexagon) and blanket rods (outer group) in position. The diameter of the blanket recess is nearly 32 in.

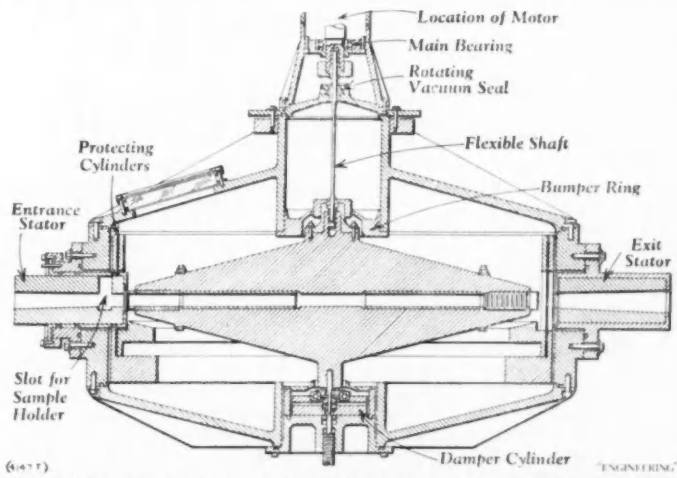


Fig. 6 Neutrons produced in the fission process are a valuable research tool. In order to obtain short bursts of neutrons, a shutter mechanism is used. In the Brookhaven fast chopper (for fast neutrons) the shutter, which is necessarily heavy to stop neutrons of all energies, must open and close in about 1 microsecond. The inertia problem is thus considerable.

Materials and Processing

The raw materials of nuclear energy are many and various, but perhaps the most fundamental are the fuels. The world's resources of uranium and thorium and their location are thus primary considerations in the development of atomic power, though in view of their high energy-to-bulk ratio, geographical distribution is not so important a factor as in the case of other fuels. Volume 6 is concerned with the geology and location of uranium and thorium ores. Volume 7, which embraces papers on nuclear chemistry and the effects of irradiation, covers a wider range of materials. It begins with a discussion of the fission process and continues with sections devoted to the chemistry of fission products and techniques for handling them. Fuel processing, solvent extraction and anion exchange are other subjects treated, together with the chemistry of the transuranic elements,

Non-irradiated adult gravid female *Trichinella spiralis* (× 250); note numerous young embryos in anterior portion of uterus and the newborn larva just expelled from the vulval opening.

Sterile adult female showing stunting of growth and degenerative cellular changes; this female developed from a larva that had been exposed to 10,240 rep cobalt 60.

Fig. 10 (above) The use of ionising radiation in the preservation of food is already well established, and in particular gamma radiation from caesium 137 has proved effective for killing the larva in meat which gives rise to trichinosis.

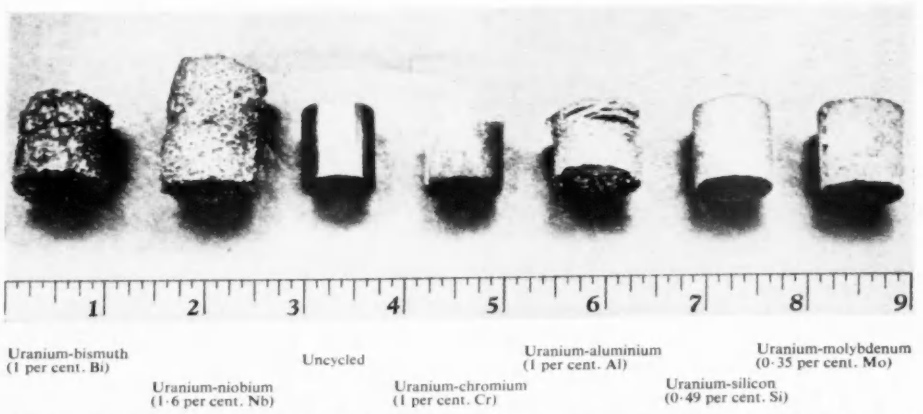


Fig. 9 Effect of 500 thermal cycles (200 to 700 deg. C.) on various uranium alloys. Original size of all specimens was about that of the uncycled sample.

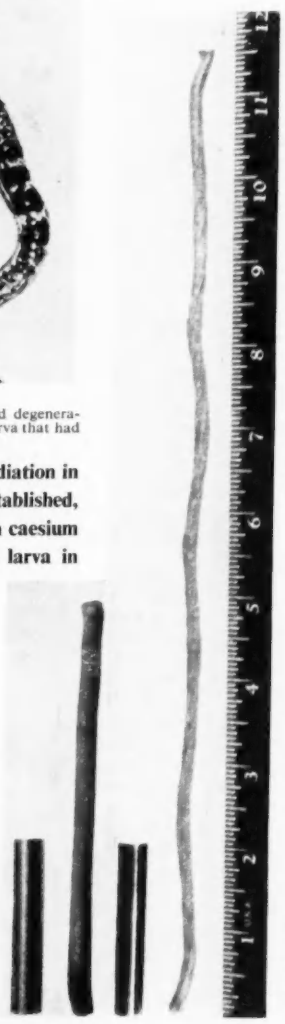


Fig. 8 (right) Deformation of uranium under thermal cycling: (left) 300 deg. C. rolled rod, uncycled; same specimen after 1,300 cycles; uncycled specimen; and (right) after 3,000 cycles; cycling between 50 and 550 deg. C.

Fig. 11 (right) Grasshoppers are being used at the Argonne National Laboratory, U.S.A., for genetic research. Biologists study the effect of radiation on the hereditary constitution of living organisms.

including plutonium. An important section deals with the effects of radiation on liquids, solids and reactor materials generally (Fig. 7). For example, the radiation stability and oxidation of organic substances are significant not only in the production of synthetic materials but also in the determination of a suitable organic liquid for use as a reactor moderator and coolant.

In Volume 8 the extraction, treatment and analysis of some important reactor materials are examined in further detail; the materials covered are uranium, thorium, heavy water, graphite, zirconium and beryllium. The last two elements, which may prove useful as canning materials for the fuel elements of higher temperature reactors, are of special interest at present. In the section on heavy-water production reference is made to the following processes: distillation of hydrogen; dual-temperature systems; distillation of natural water; electrolysis of water; simple steam-hydrogen exchange; and distillation of hydrogen combined with steam-hydrogen exchange. The chemical exchange processes are based on reactions of the form:

$$H_2O + HD \rightleftharpoons HDO + H_2$$

with separation by a process generally similar to gas-liquid absorption or liquid-liquid extraction.

Other methods mentioned, but considered to involve prohibitively high costs of energy, chemicals or materials handling, or excessive working inventory of partially enriched deuterium, are: adsorption and ion exchange, solvent extraction, fractional crystallisation, and processes involving differential reaction rates of isotopic substances, diffusion through porous membranes, thermal diffusion or differential ion migration. However, it is conceivable that if certain of these processes yielded heavy water as a by-product of some other main purpose they might prove economical.

The last of the four volumes concerned largely with materials is Volume 9, which deals with reactor technology and chemical processing. Particular topics treated are waste disposal, the alloying of the fissile and fertile elements, thermal cycling (Figs. 8 and 9), the fabrication and re-processing of fuel elements, the corrosion, heat transfer and pumping of liquid metals and the processing of homogeneous reactor fuels. The problems of the liquid-metal-fuel reactor is further considered in this volume, which deals in one section with the subject of bismuth-uranium fuels, and discusses the use of zirconium as a corrosion inhibitor.

Volumes 10, 11 and 12 are not of direct engineering interest, being concerned with the application of radioactive isotopes and nuclear

radiations in medicine, biology, agriculture, physiology and biochemistry.

Health and Administration

Legal, administrative, health, safety and ecological problems relating to mining, reactors and radioactive isotopes are covered in Volume 13, which includes some discussion of compensation and insurance matters. The accumulation of radioactive products in the earth's crust and atmosphere is examined, and a Japanese paper deals significantly with radioactivity distribution in the North Pacific Ocean. The genetic effects of radiation are considered (Fig. 10), but this is rather the domain of the three previous volumes. Atomic energy is also linked with meteorology in one contribution, though with no more controversial conclusion than that each of the two studies can be of service to the other.

Using Radioactive Isotopes

Volumes 14 and 15 are devoted to the uses of radioactive isotopes, the first including papers on specific sources and covering general problems of production, dosimetry, radiation detection and handling, and the second dealing with the application of these materials in research and industry, as in petroleum refining and thickness gauging. Their use in sterilising (Fig. 11) is also discussed in Volume 15, together with nuclear batteries and the direct conversion of nuclear energy into electric power. The development in the application of radioactive materials has largely followed from increases in their availability: at one time small and almost priceless quantities of radium were held by hospitals for cancer treatment; then it was discovered that cobalt and other substances could be made radioactive by irradiation in a reactor; but now that radioactive isotopes can be separated from reactor fission products in great quantities the problem is rather to find a sufficient number of uses. The contents of these volumes have been discussed at length in ENGINEERING (vol. 180, pages 292, 419 and 597, 1955, and vol. 181, page 337, 1956).

Science and Man

The final volume (Vol. 16) is a record and history of the Conference and includes a number of additional papers concerned with international co-operation; a record of the opening session, at which Dr. Homi J. Bhabha, the president of the Conference, delivered his address; the Conference programme; a numerical index of the papers presented; and an index of authors. Volume 16 also contains the texts of 10 evening lectures delivered during the Conference period by scientists of international reputation. Since they are of special significance and wide general interest, the lectures and their authors may be listed here: "Physical Science and Man's Position" (Niels Bohr), "High Current Accelerators" (Ernest O. Lawrence) (Fig. 12), "Principles of the Acceleration of Charged Particles" (Vladimir J. Veksler), "Radioactive Tracers and their Application" (G. de Hevesy), "Radiocarbon Dating" (Willard F. Libby), "Light Mesons" (Hans A. Bethe), "Heavy Mesons and Hyperons" (Louis Leprince-Ringuet), "Modifications of Radiation Response" (Alexander Hollaender), "Radioactive Elements in the Study of Plant Life" (Andrei L. Kursanov), and "The Future of Atomic Energy" (Sir John Cockcroft).

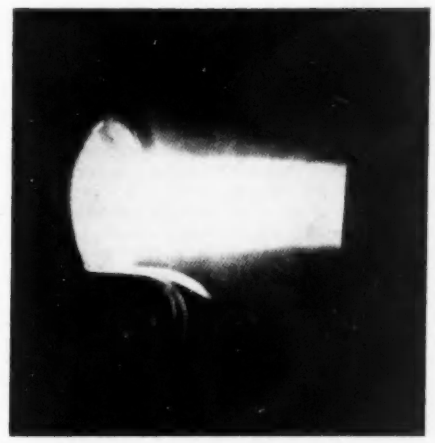


Fig. 12 Half-ampere 100 keV proton beam entering the input aperture of the high-current A48 linear accelerator at Berkeley in the United States.

The *Proceedings* are well presented and fully illustrated, with drawings, diagrams and half-tone prints. Their contents remain authoritative and largely up-to-date, though partly because publication of new information lags behind discovery and research. Two fields in which they no longer represent the present state of knowledge are nuclear fusion and the practical engineering of large fission power stations; most of the available information on this second subject has been published since the commissioning of Calder Works in papers presented at the recent British Nuclear Energy Conference Symposium. But as a foundation for nuclear science and technology, the Geneva Conference *Proceedings* will continue to be useful for many years, serving as a guide to trends in the participating countries, as a source of reference, and as a starting point.

CLEARING THE AIR

Air Pollution Handbook. Edited by PAUL L. MAGILL, FRANCIS R. HOLDEN and CHARLES ACKLEY. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street*, *New York* 36, *N.Y.*, *U.S.A.* (15 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street*, *London*, *E.C.*4. (112*s.* 6*d.*)

It is necessary to preach to the converted; converted, that is, to the view that air pollution is an abominable nuisance which must be abolished as quickly as possible. The preaching must be done in order that the limited effort available shall be directed into the most important work. It was probably wise, therefore, not to include sorry stories of the damage we do to ourselves by pollution, but to provide, in the *Air Pollution Handbook*, essays by experts on their own parts of the problem so that everyone concerned can get a balanced view. It is by a long way the best recent book from the point of view of the local authorities and industries concerned.

There is a tendency, when experts in different fields are occupied with one problem, for each to learn as little as possible of the other's disciplines; this will not do. Of course, working together with continual discussion is the best way to learn, but this is not always possible. The next best thing is to read essays such as these, written not for general readership but for that section interested in air pollution. The point is well illustrated by the meteorological case. The two chapters on meteorology in this book provide an excellent summary of the subject, and should do much to remove the naïve ideas so often expressed.

The problems are really much more complicated than some propagandists would have us believe. We have seen that the economic facts of pollution are not needed to convert us, but since pollution has become a habit it may be costly in the first place to abolish it, however high the return. We must therefore go about it in the most efficient manner, and this means knowing not only how to stop the pollution, but which sources require attention first, and when to stop them.

As an example of the absence of a sense of (economic) proportion, we may cite Lincoln power station, the dimensions of whose chimney and cooling towers were reduced from what was originally planned because they would have spoiled the dominant and beautiful position of the cathedral. Good, perhaps, in its way; but visitors to the cathedral can see the dangerous corrosion of the priceless stonework by pollution from the squalid little fireplaces of the city (the Dean's included !) which continue to foul the air unchecked. If the cathedral disintegrates before the power station is obsolete, it will in part be because the power station was not big enough to replace all the little fires. Incidents like this happen because no estimates have been made of the cost of the different sources of pollution as opposed to the cost of the damage on its own. A knowledge of those costs would give us a basis for planning.

The second question when is it economical to stop pollution, involves the idea of "meteorological control" described in the book. This simply means that if it is costly to abate the pollution it should only be done when the weather causes an accumulation that can do damage. For instance, if the gas washing at Battersea power station were not done in summer or on windy days in winter, no more damage would be done and a few hundred thousand pounds would be saved and much pollution of the river by sulphur prevented. We need, therefore, an estimate of the cost of the damage done by any power station if we are to consider whether it is worth while washing its effluents. The idea of meteorological control has been considered more in America than in England because the British climate is on the whole more conducive to the dispersion of pollution, with the consequence that any gross accumulation is regarded as an unfortunate accident. When it occurs more frequently one is less complacent.

Economic estimates will not be easy to make because, in addition to the complicated weather, the different sources in Britain are so intermingled. More observations, particularly daily and hourly ones, are needed from sensibly placed instruments. Every local authority should have the *Handbook* to help it in this.

Finally, are there any new problems imminent? The most obvious is the danger of pollution from nuclear power stations. Unless the internal design is radically changed they will have to have tall chimneys because some constituents of the pollution accumulate over long periods. A careless nation can survive (at a cost) a smoky century of endemic bronchitis; but the danger from radioactive strontium may be too great to leave to chance. Public inquiries about the building of nuclear power stations will, no doubt, deal with many controversies, but in the matter of pollution it must not be a question of one will overriding another. The problem must be solved, not arbitrated. Architects may have to design acceptable 600 ft. chimneys, not ban them as impossibly ugly and engineers may have to accept the principle that, when adverse weather is forecast, a third of the stations' output must go as heat up the chimney to ensure that the buoyancy carries the pollution away.

Every new development brings its own medical problems. We have not only radioactivity, but Diesel fumes, for example. Although the medical problem is at present unsolved, the controversy is waged largely as if it were (and the opposition were trying to hide the facts). The *Handbook* is weak on medical aspects, probably with good reason. Again we need expert guidance before we can tell the most profitable attack on the pollution, and the *Handbook* should be available to medical researchers, or they may proceed on very unrealistic assumptions about the atmosphere.

In the meantime it is important that something be done about pollution. But it should be clear that the easiest or most obvious course may have a negligible effect. If the problems are difficult it is better to be aware of them and of our ignorance, and all the time make the best estimate we can of what the answers will be, than to legislate emotionally.

JET VERSUS TURBO-PROP

AN ECONOMIC ASSESSMENT

We give below extracts from the fourteenth Brancker memorial lecture on "The Economics of Speed: an Examination of the Future Roles of Jet and Turbo-Prop Transport Aircraft," delivered recently before the Institute of Transport by Marshal of the Royal Air Force Lord Douglas of Kirtleside, G.C.B., M.C., D.F.C., chairman of British European Airways.

Air transport to-day is embroiled in perhaps the most controversial issue of the whole 37 years of its existence—the future roles of pure jet and turbo-prop engines in the propulsion of transport aircraft. The British tax-payer has invested large sums in sponsoring these new engines, and several of the aircraft in which they are installed. It is therefore essential, if he is to get maximum return on his money, that the spheres of optimum application of the two types of gas turbine should be established and then energetically exploited.

Jet transport enthusiasts claim that this type of aircraft can offer continuing reductions in operating cost and, at the same time, make possible higher operating speeds. They claim, furthermore, that the speeds will be so much higher that other types of aircraft will be put out of business.

The case for the turbo-prop rests primarily on the claim that it makes possible substantially lower operating costs than can be achieved with the pure jet. The propeller turbine transport is seen as the only choice for the carriage of the great majority of future air traffic—which will insist on the lowest possible fare. The first-class market, which is prepared to pay for the quickest possible journey, will be only a fraction of the low-fare business.

In addition, the turbo-prop is claimed to be less exacting in its operating requirements. For example, it requires shorter runways, a wider range of cruising heights is possible, there is much less external noise, landings in poor visibility or on icy runways are likely to be easier and it suffers less penalty from heavy fuel reserves to provide for diversions from the intended terminal in bad weather.

It is, however, on an assessment of the likely effect of speed and cost on their operations that most airlines are deciding their future aircraft policy. In reaching their decisions airlines have to take account of two practical aspects of the problem:—(*a*) The higher cruising speeds of the jets may give important advantages in faster journeys only over the longer distances. Thus, a jet which is even 150 m.p.h. faster than a turbo-prop will be able to offer a journey only 20 minutes shorter on a stage of 500 miles—such as London-Zürich. A time-saving of this order may not be worth having if there are significant economic and operating objections to the faster vehicle. On the other hand, at the same fare, even 20 minutes could be competitively important. There would be little merit in having a lower-cost slower vehicle if it lost most of its traffic to a competing jet and failed to achieve an economic load factor. (*b*) A slower aircraft with a lower operating cost may be attractive to operators only if they are able to pass on their lower costs to their customers in the form of reduced fares. These, in turn, would attract the traffic in spite of the lower speed. However, on international routes, lower fares are dependent on agreement between airlines at the traffic conferences of the International Air Transport Association (IATA). If the traffic conferences did not agree a fare differential between jets and turbo-props, the turbo-prop operator might easily be worse off with the lower cost but—at the same fare—less competitive vehicle.

COMPARATIVE PERFORMANCE

At the beginning of of the 1960's the American "big jets," the Boeing 707 and Douglas DC-8, are likely to offer cruising speeds close to 550 m.p.h. At that same time, the turbo-prop airliners, the later Vickers Viscounts and the first Lockheed Electras and Vickers Vanguards will be achieving speeds of 400 m.p.h. or more. As progress is made into the 1960's, the speeds of the jets will probably rise towards 575 m.p.h. while that of the turbo-props should approach 460 m.p.h. The practical effect of these speed differentials is brought out in Table I. It shows clearly the small savings in block time (between airports) and therefore in journey time (city-centre to city-centre) on the shorter journeys by using a 575 m.p.h. jet instead of a 460 m.p.h. turbo-prop. The time savings compared with the 375 m.p.h. turbo-prop are, of course, greater but they remain relatively modest over the shorter distances.

The indications are that, in hot weather, the American "big jets" will require runways about 12,000 ft. long for operations on long-stage routes such as the North Atlantic. Over shorter distances these aircraft will require about 10,000 ft., as will medium-haul jets in the class of the Convair CV-880. These runway lengths will have to be associated with pavement strengths adequate for aircraft with loaded weights of the order of 150 tons.

The increasingly large open spaces required by a modern airport are dictating sites further and further away from the centres of the cities they serve. Thus, in Sweden, Stockholm's old airport at Bromma, 5 miles from the city centre, will have to be replaced by a new airport at Ska-Edeby, 14 miles from the city. This means that a 575 m.p.h. jet using the new airport will offer a slower city-centre to city-centre journey to its passengers than a 460 m.p.h. turbo-prop using Bromma on all stages of less than about 750 miles—say, as far as Frankfurt.

Turbo-prop transports will be able to operate from significantly smaller airports than the equivalent jets. Thus, the long-range Bristol Britannia 310, intended for non-stop London-New York operation, will require a runway of about 7,500 ft. at full load. The medium-haul Britannia 100, Vickers Vanguard and Lockheed Electra have take-off distances of the order of 6,500 ft. Moreover, their lower gross weights to carry a given payload over similar distances mean that airport pavement strengths can be less, and airport construction is therefore cheaper.

COMPARATIVE OPERATING COSTS

British European Airways have made a study of hypothetical 575 m.p.h. jet transports with short, medium and long-range capabilities. These aircraft have been designed to carry a capacity payload of 25,000 lb. over stage lengths of 1,000 and 2,500 and 3,500 statute miles. The jet "paper aeroplanes" have been compared with two similar "families" of turbo-props with the same range characteristics and capable of carrying the same payload in an identical fuselage. One turbo-prop "family" cruises at 375 m.p.h., the other at 460 m.p.h. Fig. 1 compares their block speeds over different stage distances and

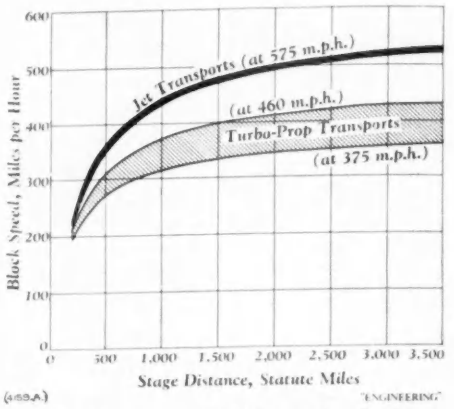


Fig. 1 Comparison of block speeds of a hypothetical jet and turbo-prop air-liners.

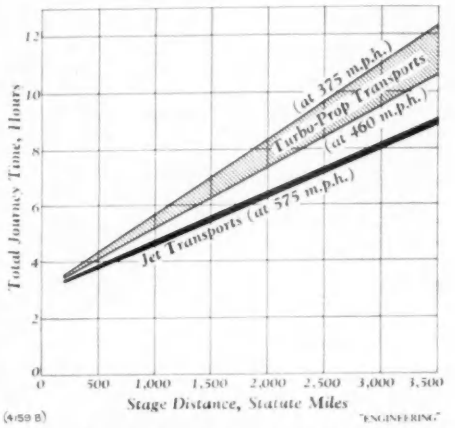


Fig. 2 Comparison of city-centre to city-centre journey times by hypothetical air-liners.

TABLE I.—JET AND TURBO-PROP COMPARATIVE SPEEDS

Stage length, statute miles	Typical stage	Block time (airport-to-airport)				
		575 m.p.h. pure jet	375 m.p.h. turbo-prop	460 m.p.h. turbo-prop	Time saving by jet competing with	
					375 m.p.h. turbo-prop	460 m.p.h. turbo-prop
		Hrs. Mins.	Hrs. Mins.	Hrs. Mins.	Hrs. Mins.	Hrs. Mins.
200	London-Paris	0 50	1 0	0 54	0 10	0 4
500	London-Zürich	1 23	1 48	1 36	0 25	0 13
700	New York-Chicago	1 42	2 23	2 03	0 41	0 21
900	London-Rome	2 03	2 55	2 30	0 52	0 27
1,100	London-Gibraltar	2 24	3 25	2 58	1 01	0 34
1,600	London-Moscow	3 17	4 47	4 01	1 30	0 44
2,500	New York-Los Angeles	4 50	7 05	5 54	2 15	1 04
3,500	London-New York	6 37	9 43	7 54	3 06	1 17

TABLE II.—LEADING CHARACTERISTICS OF 100-PASSENGER DESIGN STUDIES

Aircraft type	575 m.p.h. jet			460 m.p.h. turbo-prop			375 m.p.h. turbo-prop		
	Short haul	Medium haul	Long haul	Short haul	Medium haul	Long haul	Short haul	Medium haul	Long haul
Design stage (st. miles)	1,000	2,500	3,500	1,000	2,500	3,500	1,000	2,500	3,500
Max. take-off weight (lb.)	135,000	180,000	225,000	115,000	140,000	165,000	105,000	125,000	145,000
Engines (4 × lb. thrust or s.h.p.)	8,500 lb.	10,000 lb.	11,500 lb.	5,000 s.h.p.	5,400 s.h.p.	5,800 s.h.p.	3,000 s.h.p.	3,250 s.h.p	3,500 s.h.p
Prime cost	£1,040,000	£1,190,000	£1,350,000	£930,000	£1,010,000	£1,080,000	£800,000	£840,000	£890,000
Take-off field length (ft.)	6,000	8,100	10,000	4,600	6,200	8,000	6,000	8,000	10,000
Landing field length (ft.)	6,000	6,000	6,000	7,000	7,000	7,000	6,000	6,000	6,000

Fig. 2 illustrates the resulting journey times between city centres. Table 2 gives the leading characteristics of the resulting design studies.

" Formula aircraft cost " (that is to say, calculated theoretical direct operating cost) estimates have been prepared for the nine hypothetical aircraft studied. The results of this comparison are illustrated in Figs. 3 and 4, from which it may be seen that the 575 m.p.h. jet has formula operating costs between 3 and 9 per cent. higher than the 460 m.p.h. turbo-prop when operated over stage lengths of about the design range. However, as the stage length diverges from the design figure, an increasing economic advantage for the turbo-prop is apparent. This reaches something like 5 per cent. for the short-haul aircraft and 10 to 15 per cent. for the medium and long-haul designs. The slower 375 m.p.h. turbo-prop has significantly better economic characteristics than the 460 m.p.h. aeroplane. At its design range, the jet has a cost between 10 and 14 per cent. higher. Away from the design point, this difference increases to 16 per cent. for the short-haul aircraft and 20 to 30 per cent. for the longer-haul types.

In Fig. 5 are shown estimated formula aircraft costs for the Vickers V.840 Viscount, the Sud-Est Caravelle, the Vickers V.951 Vanguard and the Convair CV-880. These aircraft are all on order by various airlines and should be in competing service during the next three to four years.

The above comparisons have all been based on formula aircraft costs determined by the B.E.A. method. Experience shows, however, that cost estimates of this kind, particularly when they are made some years before an aeroplane enters service, are likely to be optimistic. The adjustment required also differs for turbo-props and jet aircraft and has the effect of increasing the cost differential between them.

To arrive at the total operating costs it is also necessary to add the indirect costs. Generally, the total costs are from 1½ to twice the direct costs, depending on the type of airline, where it operates, the route network, its size and its efficiency. Total costs for the Viscount and Elizabethan in B.E.A. service are at present running at about 160 per cent. of aircraft costs.

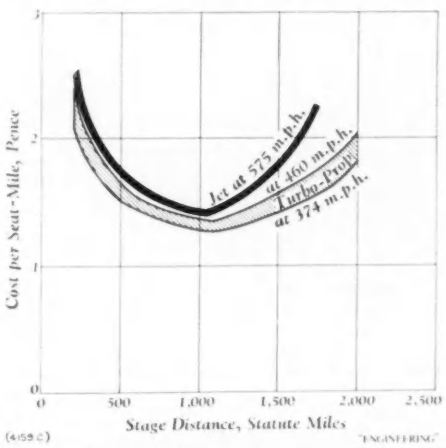


Fig. 3 Estimated direct operating costs for hypothetical short-haul air-liners.

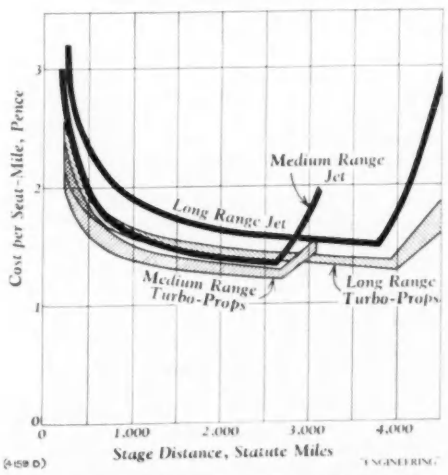


Fig. 4 Estimated direct operating costs for hypothetical medium and long-haul air-liners.

TABLE III V.701 VISCOUNT AND COMET 1 AIRCRAFT COSTS (IN 1957 MONEY VALUES)

Aircraft Type	V.701 Viscount			Comet 1		
Operator	B.E.A.			B.O.A.C.		
Type of cost	1950* formula cost	1953-54 actual cost	Actual cost when established in service	1949* formula cost	1952-53 actual cost	Actual cost when established in service (Estimated)
	£ per hr.	£ per hr.	£ per hr.	£ per hr.	£ per hr.	£ per hr.
Aircraft standing charges. Interest on capital sunk in aircraft and spares	17·6	20·5	20·9	29·9	37·0	37·0
Flying staff pay and allowances, etc. Cabin staff pay and allowances, etc.	16·7	16·1	15·2	20·1	37·3	26·2
Fuel and oil	19·4	23·8	23·8	70·0	92·6	92·6
Engineering costs	27·3	41·6	37·4	36·3	93·3	62·5
Landing fees	3·8	4·1	4·1	5·5	2·6	2·6
Total aircraft costs per hour	£84·8	£106·1	£101·4	£161·8	£262·8	£220·9
Average stage length (statute miles)	506	506	506	1,050	1,050	1,050
Average block time (hours)	2·19	2·30	2·20	2·86	2·84	2·84
Number of passengers	47	47	47	36	36	36
Aircraft cost (pence per seat-mile)	1·87	2·46	2·25	2·94	4·74	3·98
Index (formula cost = 100)	100	132	121	100	161	135

* These formula costs are not the same as the costs which were actually estimated by B.O.A.C. in 1949 and B.E.A. in 1950. The costs forecast at those dates for the Comet and Viscount were based on earlier methods of estimation.

TABLE IV.—COMPARATIVE COSTS—575 M.P.H. JETS AND 375 M.P.H. TURBO-PROPS

Range category	Point of comparison	Jet costs higher than turbo-prop costs (cost per seat-mile)		
		Formula aircraft costs, per cent.	Actual aircraft costs, per cent.	Actual total costs, per cent.
Short-haul transports (Capacity payload for a maximum of 1,000 miles)	At design range	10	18	11
	Away from design range	Up to 16–24	Up to 24–32	Up to 15–20
Medium-haul transports (Capacity payload for a maximum of 2,500 miles)	At design range	12	20	12
	Away from design range	Up to 28–30	Up to 36–38	Up to 22–24
Long-haul transports (Capacity payload for a maximum of 3,500 miles)	At design range	14	22	14
	Away from design range	Up to 28–32	Up to 36–40	Up to 22–25

PRACTICAL TURBINE EXPERIENCE

So far, only two turbine-powered aircraft have actually been used on scheduled airline services—both of them British, the de Havilland Comet 1 jet air-liner, which accumulated a grand total of commercial experience of 24,000 revenue flying hours, and the Vickers Viscount turbo-prop airliner, with a total airline experience of 442,000 hours to date.

Table III, which sets out a breakdown of B.O.A.C. Comet 1 and B.E.A. V.701 Viscount costs under a number of headings in terms of 1957 money values, shows that the actual aircraft costs experienced during the first year of airline service with the Viscount was 32 per cent. higher than the formula aircraft costs estimated on the information available two years before the aircraft went into service. The corresponding relationship for the Comet 1 was 61 per cent.

Experience since the Viscount went into service suggests that the average actual aircraft costs for the Viscount at the mid-point in its life will be reduced to a figure 21 per cent. higher than the formula aircraft costs. It is estimated that, for Comet 1, had it continued in service, the average actual aircraft costs at the mid-point in the Comet 1's life would have been reduced to a level equivalent to about 35 per cent. above the formula aircraft costs estimated on the information available two years before the aircraft went into service.

There was, therefore, a differential between the relationship of actual to formula aircraft costs for the Viscount and Comet 1 of about 12 per cent. The Comet 1, in its day, represented a far greater technical step into the unknown than the Viscount or, indeed, than will be required of the jets of the future. For this reason, one would expect the ratio of actual to formula costs for the Comet 1 to be higher than can be anticipated for future jet aircraft. However, even in the future, there is likely to be some differential between the actual/formula cost relationships of jets and turbo-props. This is primarily because of the jets' greater operational inflexibility and because of their more " sophisticated " design which tends to exaggerate the economic effect of engineering changes. A reasonable assumption in extrapolating Comet 1 experience into the future might be to assume a reduction of one-third on the 12 per cent. differential in the relationships of actual to formula aircraft costs for the Viscount and Comet 1. An arbitrary reduction of the differential to 8 per cent. has therefore been assumed in the cost estimations for future aircraft types made later in this paper.

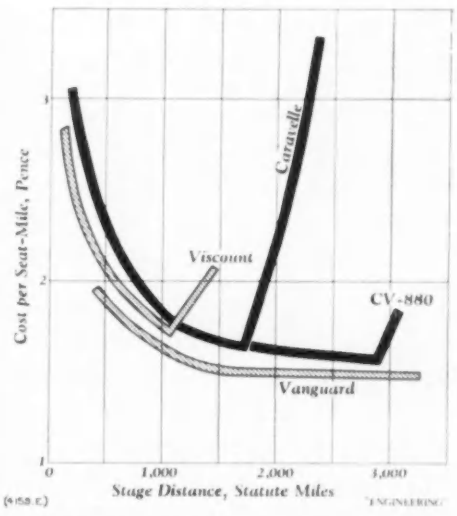


Fig. 5 Estimated direct operating costs for jet and turbo-prop air-liners on order.

Some statistics of Viscount and Comet 1

TABLE V.—Comparative Costs—575 M.P.H. Jets and 460 M.P.H. Turbo-props

Range category	Point of comparison	Jet costs higher than turbo-prop costs (cost per seat-mile)		
		Formula aircraft costs, per cent.	Actual aircraft costs, per cent.	Actual total costs, per cent.
Short-haul transports (Capacity payload for a maximum of 1,000 miles)	At design range	3	11	7
	Away from design range	Up to 5–12	Up to 13–20	Up to 8–12
Medium-haul transports (Capacity payload for a maximum of 2,500 miles)	At design range	6	14	9
	Away from design range	Up to 12–24	Up to 20–32	Up to 12–20
Long-haul transports (Capacity payload for a maximum of 3,500 miles)	At design range	8	16	10
	Away from design range	Up to 16–18	Up to 24–26	Up to 15–16

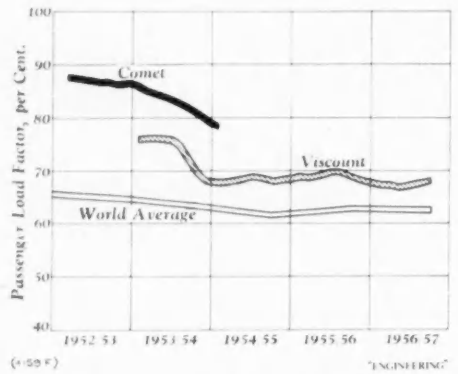


Fig. 6 Passenger load factors achieved by the Comet 1 and Viscount air-liners.

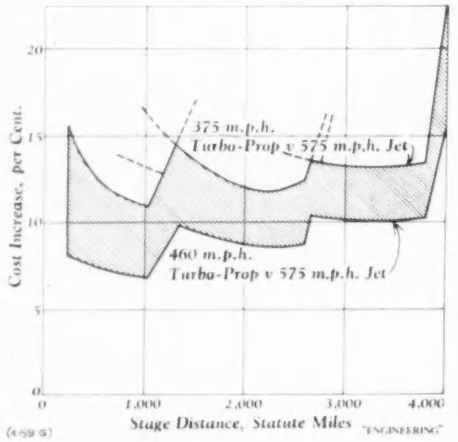


Fig. 7 Comparision of total operating costs of jet and turbo-prop air-liners.

operations are worth considering before concluding this brief examination of practical turbine transport experience. Fig. 6 brings out the very high passenger load factors achieved by B.O.A.C. with the Comet 1 which helped to make these operations profitable in spite of the aircraft's relatively high cost characteristics. They also provide some confirmation—if it were needed—of the claims of the jet protagonists of the competitive importance of speed.

COST CONCLUSIONS

Assuming the 8 per cent. differential in the actual-to-formula cost relationship already discussed, and assuming that the indirect costs are such that total costs are 160 per cent. of aircraft costs (which is the present B.E.A. figure), Table IV sets out the relationship of jet to turbo-prop costs for the three matched jet and 375 m.p.h. turbo-prop projects already examined. Table V does the same, comparing the jets with the 460 m.p.h. turbo-props. The differences in jet and turbo-prop costs are illustrated in Fig. 7.

Certain broad generalisations can now be made about the likely roles of turbo-prop and jet transport aeroplanes on the evidence which has been examined. The jet will be between 10 and 15 per cent. more expensive to operate than the turbo-prop, and the time saved by the jet will not be competitively significant on stages of less than about 500 miles. The greater flexibility of the turbo-prop and its more modest runway requirements will tend to increase the turbo-prop's economic advantage over the jet, particularly on the shorter hauls. Thus it would appear that the turbo-prop will have a long and useful "innings" on the shorter short-haul routes where its block time handicap is small. The turbo-prop should also have a useful—but probably shorter—career on long and medium hauls where its lower operating costs may give it a useful application in the lower-fare mass-travel market, particularly if a fare differential is accepted by the I.A.T.A. traffic conferences. The longer-range turbo-prop's future may, however, largely depend on whether the type succeeds in establishing itself in service before the "big jets" appear on the scene in large numbers. The recent entry into airline service of the Bristol Britannia is therefore important.

TABLE VI. *Existing Airline Turbine Transport Orders*

Aircraft type		Existing orders		
		British	Foreign	Total
Short-haul ..	Jet	Nil	12	12
	Turbo-prop	361*	53	414
Medium-haul	Jet	33	40	73
	Turbo-prop	57†	128	185
Long-haul ..	Jet	Nil	251	251
	Turbo-prop	38	Nil	38

* Including 174 Viscounts delivered.
† Including six Britannia 100 delivered.

Past experience suggests that although roughly two-thirds of the world's passenger miles will be generated on the shorter hauls, about half this traffic will be carried in medium and long-range aircraft operated on short sectors. Because of this, it is reasonable to assume that the passenger miles provided by short, medium and long-range jet and turbo-prop aircraft are divided between them as follows:—short-haul aircraft, one-third by jets, two-thirds by turbo-props; medium)haul aircraft, one-half by jets, one-half by turbo-props; and long-haul aircraft, two-thirds by jets, one-third by turbo-props.

The numbers of new transport aircraft required by the airlines between 1957 and 1970 which result from the above assumptions are as follows: short-haul jets, 800; short-haul turbo-props, 2,500; medium-haul jets, 700; medium-haul turbo-props, 800; long-haul jets, 600; long-haul turbo-jets, 500.

An investment of perhaps £3,500 million will be required from the airlines to purchase the jet equipment and a further £3,000 million will be needed for turbo-props. These orders will, however, include those already placed (listed in Table VI) which are worth some £700 million on jets and £300 million on turbo-props.

The great controversy has yet to be resolved. However, the signs are that, before they pass into history, both jet and turbo-prop are destined to play essential parts in world transport.

TESTING CONTROL SYSTEMS

New Waveform Generator

When the dynamic performance of any system—mechanical, chemical, electrical, etc.—must be determined, it is usually convenient to excite the system with a known controlled function and observe the response. Comparison of the output function with the input function, over a wide range of values of the latter, generally provides a useful measure of the dynamic behaviour of the system.

The generation and measurement of functions is best done electrically and such procedures often require transducer systems to change electrical variations into mechanical, optical, thermal variations, etc. The design of transducers is a large subject, since each individual problem requires an individual solution. The electrical equipment, however, has to meet requirements that are more standardised, and it is possible to produce instruments for use with a variety of systems.

One such instrument is the low-frequency waveform generator type LF51 manufactured by Servomex Controls, Limited, Jarvis Brook, Sussex. The unit generates both repetitive and non-repetitive functions, and sine waves from 500 c/s to 0·0005 c/s (one cycle every 33 minutes). Unlike linear systems, non-linear systems do not have a transient response which is deducible from the steady-state sinusoidal response. Thus this instrument is particularly interesting in that it can generate a variety of non-sinusoidal functions capable of providing a more realistic assessment of the performance of a non-linear system.

Basically, the LF51 provides an upper and lower voltage with various types of transition between them. A ramp function is achieved by a linear transition from one to the other. Two similar transitions, the second in the reverse direction to the first, provide either trapezoidal or triangular pulses—depending on the presence or absence of delay between transitions. Square waves are achieved by increasing the rate of transition to the limit (a rise time of 5 microsec., 10-90 per cent., is obtained). By passing the linear transition through a non-linear shaping unit a cosine-shaped wave (0-180 deg.) may be produced. It is possible for the shaping unit to be modified so that "sine-squared" or Gaussian pulses may be generated. The duration of each pulse or ramp can be varied from 1 millisec. to 1,000 sec. Very low frequencies are encountered in chemical process controllers, and the manufacturers claim that the development of the LF51 has been carried out bearing in mind the strongly expressed opinion that the most satisfactory way of measuring phase and amplitude at such low frequencies is to use a two-channel recording system.

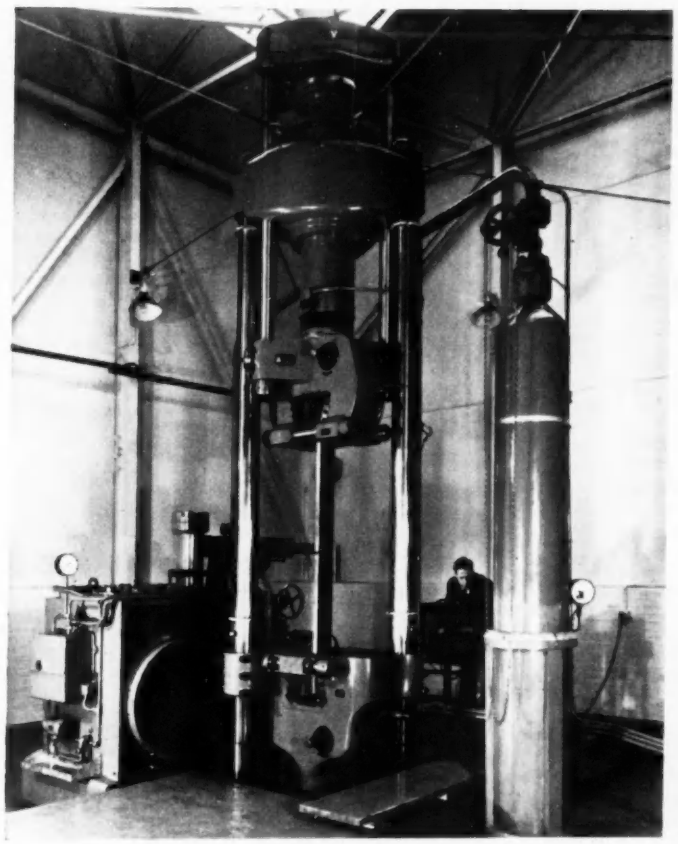
The heart of the instrument is an electronic integrator. The basic operation performed is the integration of a step function of voltage. This results in a ramp function, which may be used as such or operated on by other functions to produce the shape of step or pulse required. An output trigger pulse is available which may be used to start an oscilloscope, or similar device, before the waveform is generated.

The theoretical basis of the manner in which sine waves are produced in the instrument is approximation by adding together straight lines of various lengths and slopes. A triangular wave—a first approximation to a sine wave—is passed through a chain of diodes. The diodes are biassed in such a manner that each individual one becomes shorted out at a different value of the instantaneous voltage of the applied triangular wave. Between consecutive shortings-out the voltage varies linearly at a rate determined by the number of diodes left in the circuit. By the use of a large number of diodes the straight line segments can be made to approximate to a sine wave and the accuracy can, in theory, be made very high. However, in practice the accuracy is limited by the stability of the com-

ponents that control the biassing voltages of the diodes. In the LF51 the biassing network is made up of wire-wound resistors, and the practical sine wave is within 1 per cent. of the amplitude of a theoretical sinewave. Under these conditions the amplitude of the generated wave is 75 volts peak and the total distortion is less than 1 per cent. One consequence of the method of generating sine waves is that changes in frequency take place immediately; there is no "settling time" while instrument transients die away.

ACCELERATED FATIGUE TESTING OF AIRCRAFT COMPONENTS

NEW MACHINES FOR SHORT BROTHERS AND HARLAND



The Losenhausenwerk test machine, which can impose a 100 ton load ten times a second, is seen here being calibrated when being run in at Belfast, using a strain-gauged test bar.

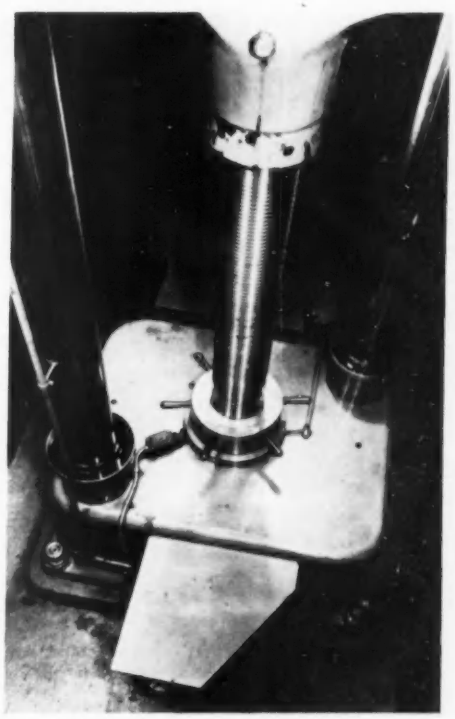
Four machines, capable of completing within 12 months the entire component - fatigue - testing programme for a major aircraft project, are being installed by Short Brothers and Harland, Limited, Belfast. The loads will be applied for periods far longer than the anticipated service requirements.

Already in use is a large machine by the German manufacturers Losenhausenwerk AG, Düsseldorf. Hydraulically operated, it can impose a load of 100 tons ten times a second. Two smaller machines for testing materials are also installed, and the range will shortly be completed with the arrival of an Avery-Schenck machine capable of imposing loads of up to 20 tons on small jointed specimens.

The Losenhausenwerk machine has already been used by Shorts to test aircraft components ranging from airliner wing-root joints to small fitted bolts. It has also been employed to investigate fatigue problems outside the field of aviation, such as the testing of specimens cut from a turbine disc used in an overseas power station. The components under test are held between jaws which apply load pulsations of varying capacities. To accommodate parts of different sizes, the lower head is adjustable by means of an electrically-actuated screw. In this way, components up to about 8 ft. long can be tested.

Loads can be maintained, throughout protracted tests, within a tolerance of $\frac{1}{4}$ ton, which represents the change of load necessary to open and close a pair of electrical contacts. When the machine has warmed up the load drift is negligible, but it may increase slightly if excessive variations of temperature cause changes in oil viscosity and volume. A decreasing load, is corrected by the controller; but if it should increase beyond a predetermined value the machine will automatically stop. If, through failure of the specimen or any other cause, the load should fall at such a rate that the pumps cannot meet the requirements the automatic control will again stop the machine.

To ensure that no vibration is transmitted to other installations nearby, the machine is mounted on an independent concrete bed resting on springs. To prepare a foundation for the machine, excavation work was carried out over an area of nearly 600 sq. ft. and to a maximum depth of 16 ft. below ground level. In all,



The central underground well of the Losenhausenwerk fatigue-testing machine, showing the main support columns and the electrically-driven screw for adjusting the lower jaws to accommodate components of different lengths.

420 tons of concrete and 12 tons of steel reinforcement were used in the foundation.

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ARC FURNACES REPLACE CONVERTERS

Quality and Economy

We have received data from Birlec Limited, Tyburn-road, Erdington, Birmingham 24, showing that the two 4 ton basic-lined electric-arc furnaces, each rated at 2,400 kVA, which they installed recently in the works of the Carntyne Steel Castings Company, Limited, Renfrew, have replaced successfully the Tropenas side. blown converters previously employed. It is emphasised that the new electric furnaces are giving better quality steel and better economy in steel production, coupled with good facilities for producing alloy steels.

The two furnaces at Renfrew regularly produce 220 tons of steel for a 60 hour week and with five heats for every 12 hours. This means an average charged weight, per furnace, of approximaterly 4·5 tons, representing an increase of 29 per cent. over the nominal capacity of the furnace. The power consumption averages 620 kWh, and the electrode consumption 9·5 lb., per ton of steel cast. The lives of the roofs are from 100 to 120 heats and of the furnace linings from 120 to 130 heats.

RE-ORGANISATION OF PLASTICS COMPANY

The increasing importance of plastics to the aircraft industry is reflected in the recent reorganisation of the board of directors of Aeroplastics Limited, Glasgow, a subsidiary of the Fariey Aviation Company, Limited. To secure a closer link-up with the parent company, four Fairey directors have been elected to the board of Aeroplastics. Mr. Geoffrey W. Hall, vice-chairman and managing director of Fairey Aviation, is now also chairman of Aeroplastics; the other three are Mr. Robert Lichley, technical director and chief engineer; Mr. John Macpherson, financial director; and Mr. A. Vines, production director.

The retiring directors consist of the chairman and managing director, Mr. A. C. Barlow, who has retired due to ill-health; Mr. Richard Fairey, who resigned on his appointment as a vice-chairman of the parent company; and Colonel A. A. Moller, who has resigned so that he may devote more time to his other activities.

Aeroplastics Limited was formed in 1935 and started production with standard pilots' seats for the aircraft industry. These were manufactured from a patented synthetic material, known as Aeroplastic, which was a combination of laminated Manila paper and phenolic resin. One of the first aircraft to use the seat was the Spitfire. The company became a subsidiary of Fairey Aviation in 1940 and production during the war concentrated on such items as propeller bosses, control columns and hand wheels, in addition to the aircraft seats.

In the post-war years, Aeroplastics has made small components for the light engineering field, and electrical and fractional-horse-power motor components. The company are now concentrating on high-quality plastics mouldings for the engineering industry, and ducting for air-conditioning systems.

Marketing

BRITISH ENGINES SOLD TO GERMANY

Exports to western Europe are the topic of the day. How shall we sell, where and when is the concern of many engineering companies. But the Common Market or free trade have played little part in one of the biggest orders placed outside Germany since the war. The West German army are to power their military vehicles with Rolls-Royce "B" series petrol engines. The B 81 will be used to power tracked vehicles.

The contract is a big one—£8½ million worth—and will involve the supply of comprehensive spares, the training of key personnel on maintenance and overhaul, and advice on the layout of equipment. From the Rolls-Royce point of view the order will very neatly follow certain orders from the Ministry of Supply, the completion of which would have caused redundancy at Crewe.

It is remarkable that Rolls-Royce should have managed to sell engines of this type to a country so skilled in their design and production. But perhaps no more so than their success in selling their "C" series Diesel engines in Canada against Cummins, Caterpillar, International, G.M.C. and other American manufacturers. In the case of Germany there is little doubt that the experience gained with the "B" series engine in military vehicles—they are standard equipment in most of the fighting vehicles of the British Army—must have weighed heavily. Nonetheless, Rolls-Royce's products fly remarkably high, over barriers of frontiers, price and prejudice that would defeat most other companies.

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Privileged Advertiser

Few of us could advertise our wares or the services we offer with the remark "sponsored by the Dollar Exports Council, the Federation of British Industries, the National Union of Manufacturers, the Scottish Council (Development and Industry) and by the Dollar-Sterling Trade Council in Canada." Were it possible to do so it would seem almost impossible to fail. Yet the advertisers in this case—Iliffe and Sons, Limited, the publishers, and Kelly's Directories Limited—are putting forward something which requires a great deal of selling—if not to the average citizen of the British Isles then to the average British manufacturer. It is the Canadian market; hence the weighty support.

Iliffe and Kelly's publish for the Canadian Association of British Manufacturers and Agencies the CABMA Register, which lists under appropriate headings British makers of industrial equipment, their products and their distributors. Iliffe call for displayed advertisements to support individual entries, claiming that the 5,000 copies that are distributed should be "constantly available throughout the year to all Canadian buyers and potential buyers of British industrial products."

There is much to be said for having a go at the Canadian market. The failures of many companies' efforts in the early 1950's have led to discouragement. But many were so ill-prepared that it would have been surprising had they succeeded. Canada is, as Iliffe say, "a rich and ever growing" market. The success of some firms in recent months suggests that many more could emulate them with advantage.

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Sales Reports Made Easy

The heart of a good sales organisation is a good sales manager who disposes of accurate live information on which he can base his planning and from which he is able to detect where and when his advice and help are needed. His constant source of live information is the sales report. The sales representatives have to stop a while, think of what they have heard, record it in note form and drive on to the next call. A good conscientious man selling a complex product may find himself at the end of the day with pages to transcribe on sales report forms.

Any prospect of improving this situation is therefore well worth attention. A. A. Jones and Shipman Limited, the Leicester firm of machine-tool makers, have installed in each of their representatives' cars a dictating machine on which sales reports can be recorded in a few minutes after making a call. In this manner they say that representatives have increased their calls by 20 per cent. The dictating machine has been with us too long for this to be surprising but it does show that modern facilities which increase productivity can take years to percolate through to even the most productivity conscious of us.

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The Importance of being Mechanised

The adoption of automation by large concerns is leading the small ones to mechanise to avoid being cut out altogether. This is the trend in the United States which, according to a sales executive of the Hyster Company, Portland, Oregon, "may, over the next 10 years, have an even more significant effect on our economy . . . than any other single factor." Mr. Moody points out that in manufacturing, handling costs range from 20 to 70 per cent. of total costs; in distribution 50 per cent. is not in the least unusual. He says: "We cannot continue with a 1956 manufacturing system and 1906 distribution methods."

The fact that an American sales manager should be preaching to his own compatriots is most revealing: the United States distributor is apparently often the small man, who should think not only of lift trucks and tractors but of conveyors, hoists, yard cranes and even palletising machines. There is rapid change in packaging, handling, storage, merchandising and delivery. Formerly the small American distributor used manual equipment or just bare hands to move his goods, to load and unload trucks and wagons and to stack for storage. Now he cannot afford to do so much longer.

Hyster, who are one of the largest manufacturers of petrol-engined industrial trucks, say they are selling lift trucks, industrial tractors and straddle-type carriers to companies employing as few as four or five people and that many thousands of their trucks have gone to companies employing fewer than 100 people. A "sizeable percentage" of these companies are first-time buyers. After this surprising admission, we are left with the impression that if Hyster have their way very few indeed will be lugging bales of clothing or coffee chests in a few months' time.

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Publicity in South Africa

An effort is being made to secure as much publicity as possible for Britain and British goods in South Africa in 1957. One reason is the golden jubilee of the British Manufacturers and Representatives Association in South Africa. Another is that the Federation of British Industries, the Board of Trade and others consider that British manufacturers should wake up to the fact that the market there is no preserve but very much an area of challenge.

The Periodicals Proprietors Association have been asked by the Board of Trade to make their contribution, and attempt to secure increased sales of British periodicals. Among the ideas put forward are the organisation of displays and the dispatch of copies for a limited period on a sale or return basis. There is little doubt that the more of our technical journals find their way to rich and growing markets such as South Africa, the more British manufacturers will benefit. Reports by manufacturers who visit the market suggest that American technical and business journals abound, and that there are no grounds whatever for Britain to take her place as the leading supplier to the market too much for granted.

Everywhere the need for publicity for British industrial goods is growing. Another note describes efforts being made in Canada.

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Centralised Spares

An indication of the immense effort involved to keep vehicles on the road is given in an announcement by Rootes Motors, Limited, about the centralisation of the supply of spare parts. A new division, Rootes Motors (Parts), Limited, has been formed and has moved into the 500,000 sq. ft. of factory space which was the Singer works.

The new stores will supply parts and accessories to Rootes distributors throughout the world, and will carry more than 50,000 items to a value of some £10 million. In addition, several millions of pounds worth of spares are carried by Rootes distributors and dealers. All this to cater for the requirements of the products made in quantities far smaller than in the case of British Motor Corporation, Ford or Vauxhall. Up-to-date storage and mechanical handling plant is being installed, along with punched cards and electronic machines.

The size of such an enterprise raises some doubts on the need to have such tremendous variety. The parts and accessories—which presumably do not include electrical ones, supplied direct to users by Lucas's own network of distributors—are for Humber, Hillman, Sunbeam and Singer cars, and Commer and Karrier trucks. About 40 per cent. of all spares output is for overseas markets. Specialist spares representatives will assist distributors and dealers at home and overseas "to operate efficient parts stores." Rootes certainly appear to be taking seriously the need to provide first-class service anywhere in the world. But could they not reduce the need for variety?

★ ★ ★

A Happy Spread

A certain plywood material was originally developed by Thames Plywood Manufacturers Limited for decking small craft. It was therefore exhibited at the National Boat Show at Olympia. Now architects are ordering it for dance floors, bar floors, the panelling of halls and staircases; furniture makers want it for cabinets. The company, in their own words, "have had to inaugurate a special production line . . . to meet orders and cope with the demand for the material inside and outside the boat building industry."

This is a classic example of what can happen when a product is developed and marketed with insufficient or with no investigation of the market. The material, "Plydek," is a resin-bonded plywood with "plank lines" set in it of a contrasting coloured wood. The main wood is Makore, one of the most dense, hard-wearing and close-fibred of all woods. A review of the possible outlets for this material, and a quantitative assessment of their value—which is becoming common practice among many engineering companies—would have provided guidance on the scale of production required. In this manner capacity could have been planned in the most economical manner to provide the correct proportions of various grades, etc., needed.

But Thames Plywood's story is a happy one: sales spread to unsuspected applications. It is when the reverse happens, as it so often does, that real trouble starts.

ATOMIC REVIEW

Not Yet Fully Extended

THE potentialities of a technical idea are seldom fully apparent until it has undergone at least some development. This is likely to be particularly true of the gas-cooled reactor, which Britain originally adopted through force of circumstances, but which now appears to offer considerable scope for extension and improvement. Already we have seen how plants little larger than Calder Hall "A" can be designed to give electrical outputs two or three times as great, and it seems probable that the imminent use of higher operating temperatures will make possible still better performances. Later, perhaps, the metallic fuel element will be entirely abandoned, being replaced by a ceramic fuel dispersed in the graphite moderator, and reactor outlet temperatures may then be sufficiently high for the gas to be circulated directly to a gas turbine without intermediate heat exchangers. Reference to the VHT (very high temperature) system was made in an article in ENGINEERING last December 7. Nevertheless, the reactor will be basically the same as those at Calder Hall—gas cooled and graphite moderated. There are many different reactor systems in the running for the later stages of nuclear power development, but we can be certain that the gas-cooled system is by no means fully extended yet.

Calder and Beyond

We referred last week to a statement made by Sir Christopher Hinton concerning experience to date on the operation of the Calder Hall "A" station; results have been generally favourable. though some minor faults have been discovered. Leakage of carbon dioxide from the system has been larger than anticipated, but this involves no hazard and makes no appreciable difference to operating costs. It has been taking place at such points as the glands of valve spindles and is progressively being remedied by conventional engineering methods. Performance of fuel elements has in general exceeded expectations, and failure of elements (which usually involves no more than a pinhole in a fuel can) has been less than that predicted from the operation of the Windscale reactors.

Fuel-Element Support.—In the Calder Hall reactors the fuel elements are stacked one on top of another, and the lower elements are therefore loaded with the weight of those above. But because the coolant enters the reactor at the bottom, these elements are at a comparatively low temperature. When the reactor was being designed, the rate at which these lower fuel elements would deflect under load was calculated and found to be satisfactory in the light of the knowledge existing at that time. Not long before the reactor became divergent, however, it was suggested, as a result of pure research work at Harwell, that the rate of bowing of these lower fuel elements might be greater than had been estimated. This theory could only be investigated by examination of fuel elements which had been exposed in the reactor. To secure the necessary information the reactor has been closed down on one occasion and fuel elements have been removed for examination. The general condition of these fuel elements is excellent, but they do show that the Harwell theory is at any rate partially correct.

The fuel elements have been in reactor No. 1 since June and during the intervening period the Authority's engineers have developed an improved method of support designed to reduce the amount of distortion. It is based on the use of a sleeve which divides the effective length of the element. (It is notable that the G.E.C.—Simon-Carves nuclear power station design employs a novel form of fuel element support; this was described in Atomic Review on February 8.) The Authority's improved type of fuel element has been introduced into reactor No. 2, which is now in full operation; and at the next routine shut-down of reactor No. 1, the fuel elements inserted will be of the new pattern.

Steel for Pressure Vessels.—The building of future stations may well be limited by the supply of thick-gauge steel plate, but the quantity of steel required per MW capacity has already been reduced in the Central Electricity Authority designs and may be expected to fall further. The French are using prestressed concrete vessels, but although this approach has been considered in Britain, it has been rejected here on grounds of technical difficulty; a thick shell of perhaps undesirable shape would be necessary and there would be serious problems with regard to charging and discharging. As far as is known, there has as yet been no statement on the use of banding to give strength to pressure vessels without adding to the problem of welding thick steel plate.

Operation and Production.—Questions have been raised concerning the operation of reactor power stations as other than base-load plants. Sir Christopher Hinton stated that gas-cooled graphite-moderated (PIPPA) type stations could be used for peak-load generation but owing to their high capital cost would be uneconomic if operated in this way. The output of Calder Hall "A" could be reduced to 5 per cent. of its full value by simply shifting the control rods. Attention has been drawn to the difference in steam conditions between the C.E.A. station designs; this, however, is a matter of turbine and steam circuit design, and the reactor outlet temperatures do not in fact differ by more than 15 deg. C. Fuel processing was also discussed. For the time being the Windscale spent-fuel processing plant will be adequate to deal with all irradiated fuel from the early C.E.A. stations, but eventually new plants must be built. As for export orders, Britain's prospects seem good, particularly with regard to Japan, and United Kingdom manufacturing capacity was sufficient to meet both home and overseas requirements.

Future.—The future of the gas-cooled reactor seems generally to lie in the raising of operating temperatures. Current work shows the high-temperature gas-cooled system to be very promising, and a high-temperature prototype is already under consideration. The difference between the high-temperature reactor using fuel elements, which is merely an extension of present designs, and the very-high-temperature system in which the fuel is dispersed should be emphasised. In the contest between the gas-cooled and liquid-metal cooled (or fuelled) reactors, the choice will be between high heat ratings (liquid-metal cooling) or comparative freedom from corrosion; the history of the sodium-cooled plant in the United States submarine Seawolf indicates the extent of the corrosion problem. As yet it is impossible to judge which design will give lower capital costs. The trend towards higher temperatures requires the development of new fuel-element canning materials, which must be workable, heat and corrosion resistant, and with low neutron absorption. Members of the United Kingdom Atomic Energy Authority are very optimistic about the prospects of beryllium, which is, however, difficult to work and toxic. But techniques employing remotely controlled machine tools are already familiar. Rumours that plastics and rubbers may prove suitable materials for fuel cans are likely to be unfounded but the use of ceramics is promising. At present, the Authority do not propose to introduce the thorium-uranium 233 cycle for power production, but they may do so in the future when the economic situation permits. Presumably present market prices for thorium are unfavourable, or the neutron economy of thorium systems is poor. Whether or not plutonium is used as enrichment for thermal reactors, it is probable that it will be most efficient as a fast-reactor fuel.

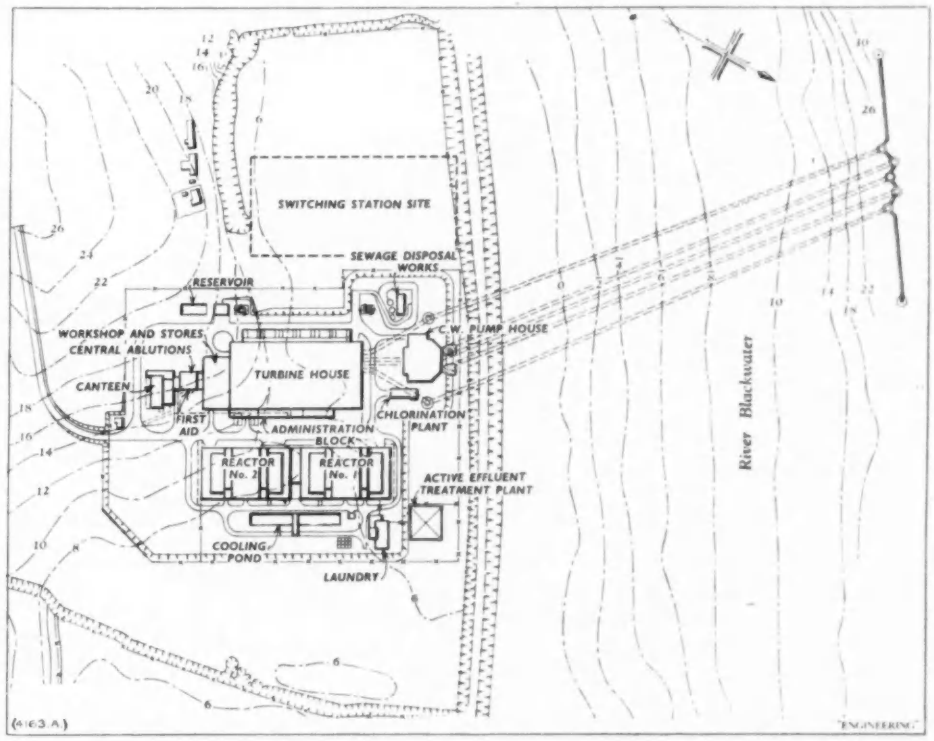


Fig. 1 Site plan of the nuclear power station being built at Bradwell, Essex, for the Central Electricity Authority. It is located on the estuary of the River Blackwater, where the soil is mainly London clay and civil engineering difficult. The contractors are the Nuclear Power Plant Company.

Bradwell and Reactor Design

At Bradwell, in Essex, the Nuclear Power Plant Company are working on one of the two nuclear power stations already commissioned by the C.E.A. In the Thomas Hawksley Lecture delivered last Friday at a meeting of the British Nuclear Energy Conference, Sir Claude D. Gibb, chairman and managing director of C. A. Parsons and Company (members of the N.P.P.C.) gave

some further details of the station and made some general remarks on gas-cooled power reactor design. Reference to the Bradwell Station, the site plan of which appears in Fig. 1, has previously been made in Atomic Review last December 21 and 28. Some sections of the lecture are summarised below.

Fuel Elements

A number of severe thermal and mechanical problems are involved in the design of the fuel elements. The use of natural uranium as the fuel limits the canning material at present to magnesium or possibly aluminium. Magnesium is superior on two counts—lower neutron capture and better compatibility with uranium—and has therefore been selected for Calder Hall and for the British stations now building, in spite of the well-known limitations in the physical properties of this metal. With magnesium the maximum surface temperature of the fuel can is limited to approximately 842 deg. F. (450 deg. C.) and the aim in design is therefore to obtain the optimum between the conflicting demands of high outlet gas temperature, high heat rating in the fuel, and an economic pumping power.

Parameters.—The choice of a suitable heat-transfer surface is further complicated by nuclear considerations. The amount of metal in the can, the channel diameter and the disposition of the fuel are restricted within certain limits by the nuclear design. The "optimisation" of all these parameters is a formidable problem which is always present as new surfaces and canning materials are developed and as further experience is obtained on core design with respect to fuel rod geometry.

Mechanical Problems.—The mechanical problems are concerned with the support of the elements in the channel, and the forces imposed on the fuel and canning material by the method of support. Consideration must also be given to the handling of the element during charge and discharge operations at power, and the strength of the elements must be sufficient to resist damage under these conditions

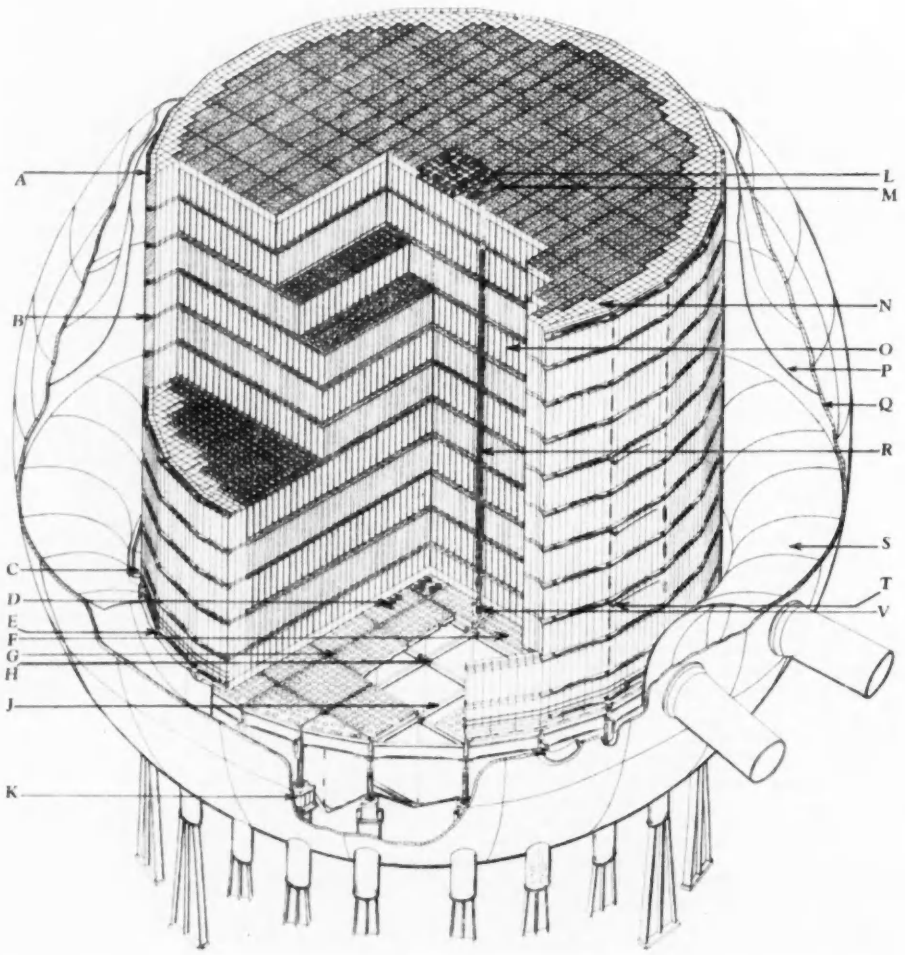
Phase Change.—Natural uranium changes its crystalline structure at about 1,202 deg. F. (650 deg. C.). Though this in itself is not significant the considerable change in volume accompanying it can lead, especially if repeated several times, to the complete loss of the mechanical strength of the fuel bar, and, what is more important, to the destruction of the container surrounding it, thus allowing fission products to escape. Consequently, for the time being, the temperature at which this α-β transition occurs dictates the temperature limit of the reactor.

Optimisation.—For nuclear reasons, the shape of the uranium should be such that the ratio of surface to volume is small, but this is in direct contrast to the requirements for maximum heat removal. Practical reasons of support preclude the use of spherical fuel elements and, with one cylinder per channel, the fuel-rod optimisation requires a diameter slightly over 1 in. Uranium is such a bad heat conductor that with the reactor on load there is a temperature drop of about 100 deg. C. from centre to periphery of the fuel rod. A further, though smaller, temperature drop occurs at the boundary between the uranium surface and the can surrounding it. The temperature drop in can wall and fins is small, but that between can surface and cooling gas is appreciable and so is that between cooling gas and working fluid. All those temperature drops, which constitute thermodynamically irreversible losses, are a challenge to the applied physicist.

To reduce the temperature drop, we should work at high Reynolds numbers, apply large secondary areas, and create surface configurations which produce high heat transfer with relatively low pressure drops. High Reynolds numbers necessitate, in order to keep pumping power within acceptable limits, high gas pressures or short channels. The gas pressure is limited by the pressure shell, which is large and hot. Shortening of the channels leads to an increased diameter-to-height ratio of the core and thus reduced neutron economy, as well as uneconomic design of the pressure vessel.

Surface Configuration.—Applying large secondary areas leads to increased neutron capture which, particularly with natural uranium, soon exceeds acceptable limits, but also its thermal effectiveness falls if the can fins become either too long or too close. Hence it is to surface configuration that special attention must be given. The thermal conductivity in gases being low, the aim must be to scour the hot fuel-element surface continuously by cooling gas, which is as nearly as possible at bulk gas temperature. This is best achieved if the gas which has been heated by contact with the fuel element is periodically transferred to, and replaced from, the main gas stream. It is important that this process be accomplished with the formation of few free vortices, which tend to increase the pressure drop without correspondingly increasing heat transfer. A considerable advance has been achieved by such a development.

Support and Canning.—The uranium in a power reactor will be at temperatures in the range 392 to 1,112 deg. F. (200 to about 600 deg. C.), depending upon the position of the element in the core. At the higher temperatures, the uranium is relatively weak and there is also evidence that creep may be accelerated by irradiation in the low-temperature portion of the reactor. Therefore the uranium must be arranged so that the forces imposed by its own weight are relatively small or, alternatively, supported continuously along its length to resist distortion. Under irradiation, volume changes occur in the uranium, and the canning material must be sufficiently ductile to absorb these changes without splitting and thus exposing the uranium to the gas. The sealing of the ends of the can, the restraint applied by the extended surface and the metallurgical properties of the canning material are each important factors.



A Topside restraint
B Intermediate side restraint
C Gas seal
D Graphite support bearing
E Bottom side restraint and radial keys
F Support plates
G Levelling screws
H Levelling pads
J Diagrid
K Roller supports
L Charge pan
M Charge pan support
N Reflector bricks
O Moderator bricks
P Gas baffle
Q Pressure shell
R Fuel element
S Toroidal shield
T Wigner growth measuring device
V Fuel element support lantern

Fig. 2 Section through the core of one of the two reactors for the Bradwell station.

Reactor Vessel

In the construction on site of large vessels made from thick plates, brittle fracture is a definite hazard since the danger of this increases with the size of the vessel, the thickness of the plates and the depth of the welds which, besides increasing the stress due to welding, increases the difficulty of locating defects. Once the vessel has been constructed and stress relieved the danger of brittle fracture is diminished but not eliminated, since, although the plant operates at a temperature well above the transition temperature of all steels, it is subjected to a pressure test while cold before being charged; it is almost certain to be allowed to cool sometimes during its life; and it is known that irradiation raises the transition temperature of the steel.

Brittle Fracture and Creep.—The danger of brittle fracture in pressure vessels can be reduced by using a low-carbon high-manganese aluminium-killed steel with a low transition temperature, that is, a high notched bar toughness at low temperature. But such steels have poor creep properties at high temperatures. Silicon-killed carbon steel has been used extensively in high-temperature plant and has good

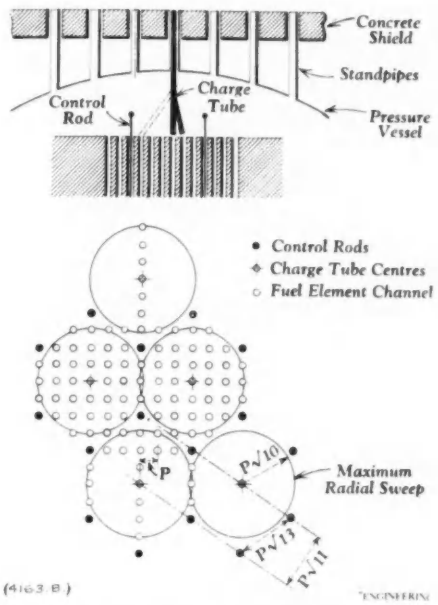


Fig. 3 Control rod and charging system for gas-cooled graphite-moderated reactor.

stress/temperature properties but would be likely to fracture on site in cold weather.

One solution is to use a silicon-killed, high-manganese, low-carbon steel and thus obtain the high-temperature properties associated with boiler quality steel suitable for high-temperature service combined with a fairly low transition temperature. Another solution is to obtain, by the addition of alloying elements, a steel with satisfactory stress/temperature properties and a sufficiently low transition temperature. A steel that appears to fulfil those requirements has been developed and is under long-term high-temperature/high-stress testing.

Double-Shell Construction.—An obvious solution to this difficult problem is to build a double-shell vessel in which a thin inner shell that takes the temperature is made from a suitable steel while a thick outer shell that takes the pressure is kept cool and can therefore be made from an aluminium-killed steel. Like many first solutions in engineering problems, the difficulties increase as detail design develops. The double-skinned reactor vessel becomes less promising when endeavouring to accommodate gas ducts, control rods, and charge-discharge standpipes.

Austenitic Steels.—Were it possible to increase gas temperatures to the point that austenitic nickel-chromium steel became economic for the pressure vessel, the problem might be simplified, since this steel combines a high resistance to brittle fracture with good mechanical properties at high temperature.

Corrosion.—Allowance in design must be made for the corrosion by hot carbon dioxide on the pressure vessels, ducts, circulators, and heat exchangers. Experiments have determined the wastage rates for the different steels used and adequate margins allowed.

Reactor Core.—Fig. 2 shows a section through the core of the reactors for the Bradwell station. The machining of the graphite blocks calls for a high degree of accuracy, to ensure the correct alignment of fuel-rod channels and to prevent neutron streaming at joints, yet still allowing for some measure of Wigner growth. The geometry of core design demands great patience and critical analysis.

Refuelling

For several reasons, including the containment of maximum size of core in a given pressure vessel, load of duct work, better natural circulation in the event of circulator failure, stress and differential movements in the core and pressure vessel, a core with vertical channels is preferable for power reactors. Refuelling has therefore to be carried out completely either from above or below or by passing new fuel in at the top and spent fuel out at the bottom. The last method has many attractions but requires twice the equipment and cannot be justified economically. Systems for refuelling from below have been devised, but they involve the insertion of relatively complex mechanisms into the pressure vessel and operating rams into the core. Thus it is possible that their reliability may be less than the simple mechanisms which are gravity assisted when charging from above.

It is at least highly desirable that refuelling on load be carried out without interference to the control system. This implies the use of separate standpipes for refuelling and control rods. The necessity to achieve a minimum ratio between fuel channels and control rods in the core determines a minimum pitch of the control-rod standpipes. The problem is to be able to insert charging standpipes between the control standpipes without weakening the pressure vessel, while maintaining adequate strength and the shielding properties of the reactor-roof biological shield, to achieve satisfactory coverage of fuel channels below the charging standpipes and to avoid interference between the control rods and charging mechanism which has to be inserted into the vessel. A typical arrangement which meets these requirements is shown in Fig. 3.

Details of Bradwell Station

The major particulars of the nuclear station at Bradwell are as follows.

Guaranteed net electrical output 300 MW.

Reactor vessels: two reactors each contained in a sphere of 66 ft. in diameter in 3 in. thick special steel.

Heat exchangers: six heat exchangers or boilers per reactor with dimensions substantially similar to those at Calder Hall but with double the unit heat output.

Gas pressure: carbon dioxide circulated at 10 atmospheres pressure.

Steam conditions: dual pressure cycle with steam at 730 lb. per sq. in. gauge, 700 deg. F. (370 deg. C.) and 180 lb. per sq. in. gauge, 700 deg. F.

Cycle efficiency: net cycle efficiency taking into account all station auxiliaries will exceed 28 per cent.

Turbines: six main turbo-alternators each of 52 MW., and three auxiliary turbo-alternators, which together supply power directly to the national grid, to the station auxiliaries, and to the variable-speed reactor gas circulators; the total installed capacity of all machines is 390 MW, which includes a margin for subsequent improvements in reactor performance; one of the auxiliary turbo-generators serves as a standby for the other two; the main turbines have two cylinders with twin exhausts and are arranged across the station.

Fuel charging: reactor designed for continuous re-charging of fuel while remaining at full output.

Goliath or gantry crane: the compact arrangement of reactor buildings seen in Fig. 1 has made possible the employment of a new tool for rapid erection of the station. This is a Goliath crane of height 140 ft., span 167 ft., lifting capacity 200 long tons.

General Notes

Contract for Berkeley Detection Equipment

Dowty Nucleonics Limited (a member of the Dowty Group) has now been informed of the intention of the A.E.I.-John Thompson Nuclear Energy Company to place a contract with them for equipment for the detection of faulty fuel elements in the Berkeley station. The principle of operation is similar to that employed at Calder Hall, and consists in detecting the contamination of samples of the coolant gas from each fuel-element channel. The large number of channels to be monitored has made necessary the design of a complete pressurised system whereby gas samples are automatically routed from every channel to radioactivity detectors. The equipment occupies two rooms in each reactor. The design has been carried out by a team of engineers at Brockhampton Park, Gloucestershire, and the resources of the Dowty Group will be used for production. It is expected that the equipment will be completed within two years.

Papers and Discourses

The outlook for gas-cooled reactors with particular reference to attainment of higher operating temperatures may be among subjects discussed in a paper to be presented before the Swedish Ingeniors Ve:enskaps Akademien on March 15 by Sir Christopher Hinton.

The work of the European Organisation for Nuclear Research (CERN) will be described in a discourse to be delivered by Sir Ben Lockspeiser, President of the Organisation's council, at the Royal Institution, 21 Albemarle-street, London, W.1, on March 8. Reference will be made to the 600 MeV synchro-cyclotron and the 25 GeV proton synchrotron being built for the Organisation at Meyrin near Geneva to provide co-operative facilities for the 12 participating countries. The lecture will be illustrated.

Conference

"Atomic Energy in Industry" is the subject of the fifth annual conference of the National Industrial Conference Board, 460 Park-avenue, New York 22, to be held at the Benjamin Franklin Hotel and Convention Hall, Philadelphia, Pa., on March 14 and 15. Radioisotopes, economic factors, hazards, metal markets, radiation chemistry, legislation, commercial power reactors (natural and enriched fuels), processing, waste disposal and the long-range outlook will be among the topics covered.

Nuclear Research Centre

A National Institute for Research into Nuclear Science is to be established in Britain. This decision has recently been announced by the Financial Secretary to the Treasury, Mr. Enoch Powell, and was reached after consultation between the University Grants Committee, the Atomic Energy Authority and the university departments concerned. The Institute will provide, for common use by universities and others, facilities and equipment beyond the scope of individual universities and organisations. It is hoped that the Institute will include a particle accelerator capable of yielding intense beams of energetic particles such as those planned or building in certain oversea establishments. The Government propose that the Institute be financed largely by grants through the Atomic Energy Authority and be managed by a board comprising representatives of the U.K.A.E.A., the universities, the University Grants Committee, the Royal Society and the Department of Scientific and Industrial Research. Lord Bridges has accepted appointment as chairman.

Research Sites

Early this month, the Minister of Housing and Local Government, Mr. Henry Brooke, granted planning permission for the development of the 688 acre site at Winfrith Heath, Dorset, as an atomic energy research station associated with the Atomic Energy Research Establishment, Harwell.

The report that a research establishment of a similar nature may be built at Talsarnau in Merioneth has been discounted.

Reactor Fuel as Tape

Five miles of plastic tape laden with enriched uranium will be used in experiments to help determine the reactor design for one of America's first nuclear power plants. This is revealed in the *Columbia Engineering Quarterly* (organ of the Columbia University School of Engineering). Fuel elements of enriched uranium for a test reactor will comprise uranium-diffused plastic tape, sandwiched between thorium converter plates. It is said to be the first time that thorium has been utilised in a reactor. In addition to providing a dispersal medium for uranium oxide, the tape will constitute an added safety device: in the event of an excessive power rise in the core, gas bubbles will form in the plastic, forcing an automatic shut-down of the nuclear reaction. To produce the large amount of uranium tape the experiment requires, special extrusion production machinery has been built. The equipment disperses the powdered uranium in the polyethylene tape, clads it with pure plastic tape, cools it, and cuts it to the desired width.

Welding Graphite

Scientists of the National Carbon Company have discovered how to weld graphite, according to the quarterly mentioned in the previous paragraph. This technique may enable graphite sheets and panels to be prefabricated for the moderators of nuclear reactors. If graphite is heated under pressure, vaporisation is prevented

and it can then be melted. This has led to the production of new forms of graphite having a much more highly ordered crystalline structure than artificial graphite has at present. Thus pieces of graphite to be joined are placed in an atmosphere of the inert gas argon under high pressure; they are then brought into contact and a direct current passed through them. They are then separated slightly so creating an arc, the heat of which combined with the high pressure causes melting and completes the union. Reference to this process has already been made in Atomic Review.

New Isotopes

Five new isotopes of the artificial element einsteinium (atomic number 99) have been prepared by two teams of scientists at the University of California. The isotopes, of mass number 248, 249, 250, 251 and 252, were made by bombarding the artificial elements berkelium (97) and californium (98) with alpha particles (helium neuclei) and deuterons (deuterium or heavy-hydrogen nuclei) by means of a particle accelerator. These discoveries were reported in the *Physical Review*. Artificial in this context means not naturally occuring.

Anyone Can Be Wrong

Scientists are often encouraged to prophecy where current discoveries may lead us, so it seems rather ungenerous to quote them when they prove to be mistaken. Yet to do so may sometimes help us to realise how capricious events can be, and to recognise that what seems fanciful to-day may to-morrow be a commonplace. A book by a scientist of world-wide reputation published in 1940 contains the following passage:

"A few years ago we used to read sensational stories about what would happen when atoms were split. The coalminers were to be put out of work by atomic power. A single bomb would liberate enough energy to destroy a whole city. And so on. Unfortunately the prophets had forgotten to do a few little calculations. The sun turns out energy at sixty horse-power per sq. in., which sounds very impressive. But if we make the calculation in a rather different way, we find that it is only producing one horse-power for every three thousand tons of its weight. I am an optimist, and I hope that within a century it will be possible on earth to construct a motor using atomic energy as efficient as the sun. If so, it will probably weigh a ton, and develop several mousepower! It is true that it will not need refuelling for a good many thousand million years, but it will not earn a thousandth of a per cent. interest per year on its cost. That figure will perhaps be exceeded later on, but the universe is pretty solidly constructed, and atoms are remarkably tough, so I think many generations will elapse before atomic power is of practical importance." (It should be noted that the scientist in question is not a physicist, and that his contributions in his own field have been many and enduring.)

The carbon-cycle fusion reaction, supposed to be the source of the sun's energy, may indeed never be usefully reproduced on earth (see ENGINEERING, vol. 182, page 125, 1956), but this does not exclude the application of other nuclear reactions including some form of fusion. In any case, it is now indisputable that the energy of the atomic nucleus can be used by man as a source of power, though so far we have only succeeded in controlling the fission reaction.

Who could have foreseen that somewhere among the elements was one which had been designed apparently with an eye to man's convenience, an element which produced not only heat when split but also neutrons of sufficient energy to cause further splitting and hence a continuous reaction? Optimism might be reasonable in the layman, but not in the scientist, who knows how many unlikely circumstances must combine to achieve a desired result. We might therefore conclude that what seems improbable to the informed mind to-day may be established fact to-morrow. On the other hand, we might remember that history seldom falls in the same place twice.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

HOVE
Discussion on "Cathode-Ray Tubes." Brighton and Hove Branch. New Imperial Hotel, First-avenue, Hove. Wed., Feb. 27, 7.30 p.m.

LIVERPOOL
"Trends in Developments of Electric Traction," by J. H. Cansdale. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Mar. 1., 7.30 p.m.

British Institution of Radio Engineers

LONDON
"Some Applications of Nucleonics in Medicine," by E. W. Pulsford and N. Veall. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Feb. 27, 6.30 p.m.

British Interplanetary Society

LONDON
"Design and Application of Solid Propellant Rocket Motors," by E. T. B. Smith. Caxton Hall, off Victoria-street, S.W.1. Sat., Mar. 2, 6 p.m.

Building Centre

LONDON
Film: "The Seed is Sown," exhibited by the Mechanical Handling Engineers' Association. Wed., Feb. 27, 12.45 p.m.

Chemical Society

BRISTOL
"Living Molecules," by Professor J. D. Bernal. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Feb. 28, 5.15 p.m.

OXFORD
"Polonium," by Professor W. Fernelius. Oxford Branch. Physical Chemistry Laboratory, The University, Oxford. Mon., Feb. 25, 8.15 p.m.

ST. ANDREWS
"Phosphorus Chemistry: Past, Present and Future," by Dr. D. S. Payne. Chemistry Department, St. Salvator's College, St. Andrews. Fri., Mar. 1, 5.15 p.m.

Illuminating Engineering Society

LONDON
"Open Space Lighting," by H. F. Stephenson and W. Peirce. E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Feb. 26, 6 p.m.*

LEEDS
Discussion on "Whither Street Lighting?" Leeds Centre. E.L.M.A. Lighting Service Bureau, 24 Aire-street, Leeds 1. Mon., Feb. 25, 6.15 p.m.

LEICESTER
"Lighting for Photography," by R. W. Unwin. Leicester Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester. Mon., Feb. 25, 6 p.m.

Incorporated Plant Engineers

LONDON
Annual General Meeting. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Feb. 26, 7 p.m.*

CARDIFF
Discussion on "Heating and Ventilation in Modern Works." South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Feb. 26, 7.15 p.m.

LEEDS
"Fuel and the Future," by Dr. A. L. Roberts. West and East Yorkshire Branch. The University, Leeds. Mon., Feb. 25, 7.30 p.m.

SHEFFIELD
Discussion on "The Interpretation of the Clean Air Bill." Sheffield Branch. Grand Hotel, Sheffield. Thurs., Feb. 28, 7.30 p.m.

SOUTHAMPTON
Annual General Meeting. Southern Branch. Polygon Hotel, Southampton. Thurs., Feb. 28, 7.30 p.m.

Institute of Fuel

LONDON
"Measurements of Size of Droplets from Convergent-Divergent Nozzles Used in Oil Burners for Steel Furnaces," by E. J. Burton and J. R. Joyce; and "Flow and Disintegration of Thin Sheets of Visco-Elastic Fuels," by Dr. N. Dombrowski, Dr. P. Eisenklam and R. P. Fraser. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Feb. 27, 5.30 p.m.*

Institute of Marine Engineers

BRISTOL
Annual General Meeting (Members only), and Film Evening. West of England Section. Grand Hotel, Bristol. Mon., Feb. 25, 7 p.m.

SWANSEA
"Diesel Hydraulic Propulsion," by F. J. Mayor. Junior Lecture. South Wales Section. Swansea Technical College, Mount Pleasant, Swansea. Wed., Feb. 27, 7 p.m.

Institute of Marine Engineers and Institution of Naval Architects

PORTSMOUTH
"Welded Aluminium Ships' Structures," by Dr. E. C. B. Corlett. Southern Joint Branch. Portsmouth College of Technology, Portsmouth. Tues., Feb. 26, 7.30 p.m.

Institute of Metals

BIRMINGHAM
"Nickel Alloys with Special Properties in the Field of Physics and Electrical Engineering," by C. Gordon Smith. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham. Thurs., Feb. 28, 6.30 p.m.

Institution of Chemical Engineers

CHESTER
Open Meeting. North Western Branch. Grosvenor Hotel, Chester. Tues., Feb. 26, 7 p.m.

Institution of Civil Engineers

LONDON
Discussion on the "Report on Engineering Education in the Soviet Union." Joint meeting with the Institutions of Electrical and Mechanical Engineers. Mon., Feb. 25, 5.30 p.m.*
"The Planning and Design of the New Hong Kong Airport," by Henry Grace and J. K. M. Henry. Airport Division. Tues., Feb. 26, 5.30 p.m.*

ABERDEEN
"Jetty Design with Particular Reference to Prefabrication," by D. H. Little. Edinburgh and East of Scotland Association. Palace Restaurant, 160 Union-street, Aberdeen. Fri., Mar. 1, 7.45 p.m.

SCUNTHORPE
"Prestressed Steel Lattice Girders," by R. A. S. Jenkins. East Midlands Association. Blue Bell Hotel, High-street, Scunthorpe. Wed., Feb. 27, 6.15 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "The Analysis of Waveforms," opened by A. Cooper and D. A. Drew. Measurement and Control Section. Tues., Feb. 26, 5.30 p.m.*
"Mechanical Strength of Power Transformers in Service," by E. T. Norris. Supply Section. Wed., Feb. 27, 5.30 p.m.*

HULL
"Germanium and Silicon Power Rectifiers," by T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., Feb. 28, 7.15 p.m.

NEWCASTLE-UPON-TYNE
"Development of Transportable Thermal-Storage Space Heaters," by E. Bates; and "Electrical Floor Warming," by J. W. Moule and W. M. Stevenson. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Feb. 25, 6.15 p.m.

WEYMOUTH
"Analogue Computers," by R. Postlethwaite. Southern Centre. South Dorset Technical College, Weymouth. Fri., Mar. 1, 6.30 p.m.

Institution of Engineering Designers

LONDON
"The Practical Application of Production Engineering Research," by Dr. D. F. Galloway. Thurs., Feb. 28, 6.45 p.m.

Institution of Engineers-in-Charge

LONDON
"Electric Lamps," by A. D. S. Atkinson. E.L.M.A. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Wed., Feb. 27, 6.30 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Paddle Wheel Research—Part III," by H. Volpich and I. C. Bridge. Tues., Feb. 26, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

GLASGOW
"Storage of Oil Fuel," by T. Chippindale. Scottish Branch. Scottish Building Centre, 425 Sauchiehall-street, Glasgow, C.2. Tues., Feb. 26, 7 p.m.

LIVERPOOL
Discussion on "Heat in the Home," opened by G. Braithwaite.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester 3.
Prestressed Concrete Development Group, Terminal House, Grosvenor-gardens, London S.W.1. (BELgravia 6661.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

Liverpool Branch. College of Building, Clarence-street, Liverpool. Wed., Feb. 27, 6.30 p.m.

Institution of Highway Engineers

LONDON
" The Law and Road Safety," by J. J. Leeming. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Fri., Mar. 1, 5.30 p.m.

Institution of Locomotive Engineers

LONDON
" Some Aspects of Locomotive Boiler Feed Water Treatment," by A. J. Parsons; " A Brief History of Locomotive Feed Water Treatment on the London Midland Region of British Railways," by J. S. Hancock. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Feb. 27, 5.30 p.m.*
LEEDS
" Diesel Locomotive Repairs," by T. F. B. Simpson. North Eastern Centre. Great Northern Hotel, Leeds. Thurs., Feb. 28, 6.45 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on " Conversion from Coal to Oil Firing." Steam Group. Tues., Feb. 26, 6.45 p.m.*
Discussion on " Problems in the Design of Valves for Liquids." Hydraulic Group. Fri., Mar. 1, 6.45 p.m.*
BRISTOL
Automobile Division Meeting. Western Branch. Royal Hotel, Bristol. Thurs., Feb. 28, 6.45 p.m.
CARDIFF
Thomas Lowe Gray Lecture on " Salvaging of Ships, with Special Reference to the Empress of Canada," by Captain W. R. Colbeck. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Feb. 26, 6 p.m.
MANCHESTER
" Training for Management," by L. Landon Goodman. North Western Blanch. Engineers' Club, Albert-square, Manchester. Thurs., Feb. 28, 6.45 p.m.
SHEFFIELD
" A Criticism of the Technical Education of Recently Qualified Engineers," by P. P. Love. Yorkshire Branch. The University, St. George's-square, Sheffield. Wed., Feb. 27, 6.30 p.m.

Institution of Production Engineers

BRISTOL
" Automation," by S. P. Woodley. Western Section. University Engineering Laboratories, University-walk, Bristol 8. Wed., Feb. 27, 7.15 p.m.
LINCOLN
" Electronic Control," by J. A. Stokes. Lincoln Section. Ruston Club, Lincoln. Thurs., Feb. 28, 7.30 p.m.
SHREWSBURY
" Influence of Production Problems on Modern Machine Tool Design," by C. A. Sparkes. Shrewsbury Centre. Technical College, Shrewsbury. Wed., Feb. 27, 7.30 p.m.
SOUTHAMPTON
" Milling versus Broaching," by A. R. Hambidge. Southern Section. Polygon Hotel, Southampton. Thurs., Feb. 28, 7.15 p.m.

Institution of the Rubber Industry

SOUTHAMPTON
" Analysis of Accelerators and Antioxidants," by Dr. C. A. Parker. Southern Section. Civic Centre, Southampton. Fri., Mar. 1, 8 p.m.

Institution of Structural Engineers

LONDON
" Factory in Concrete for the Prestressed Steel Co. Ltd., Stratton St. Margaret," by D. H. New and R. Sanders. Thurs., Feb. 28, 6 p.m.
BRISTOL
" Practical Aspects of Recent Structural Welding Developments," by W. H. Diamond. Western Counties Branch. The University, Bristol. Fri., Mar. 1, 6 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., Mar. 1, 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
" Application of Modern Gas Dynamic Theories to Exhaust Systems of Internal-Combustion Engines," by R. S. Benson. Wed., Feb. 27, 6 p.m.

Manchester Metallurgical Society

MANCHESTER
" Mechanism of Diffusion," by A. D. LeClaire. Central Library, Manchester. Wed., Feb. 27, 6.30 p.m.

Prestressed Concrete Development Group

LONDON
" Runway at Maison Blanche Airfield, Algiers," with film, by A. Mayer. Royal Empire Society, Northumberland-avenue, W.C.2. Mon., Feb. 25, 6 p.m.

Royal Aeronautical Society

LONDON
" Recent Advances in the Design of Aircraft Tyres and Brakes," by H. W. Trevaskis. Tues., Feb. 26, 7 p.m.

Royal Statistical Society

LEICESTER
" Electronics and the Automatic Office," by J. C. Masters. Leicester Industrial Applications Group. College of Technology, The Newarke, Leicester. Thurs., Feb. 28, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
" Metallurgical Aspects of Creep-Resisting Steels," by D. J. Murray. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Feb. 26, 7 p.m.

Society of Instrument Technology

LONDON
" The Determination of Parameters of a Controller by Simple Frequency Measurements," by Dr. J. H. Westcott. 26 Portland-place, W.1. Tues., Feb. 26, 7 p.m.*

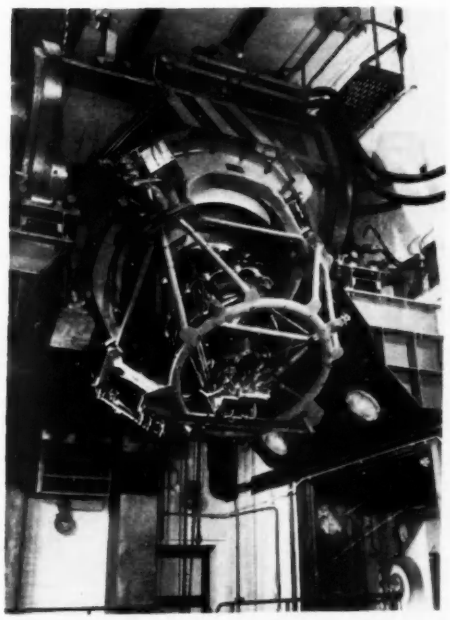
Women's Engineering Society

LONDON
" Veteran Cars," by J. Shearman. Central Electricity Authority, Winsley-street, W.1. Tues., Feb. 26, 7 p.m.*

A NEW ANGLE ON ENGINES

TILTING TEST BED FOR HELICOPTER UNITS

Helicopter engines usually operate for long periods at angles that are very different from those encountered in the engines of conventional aircraft. Consequently the design of helicopter engines poses a number of individual problems, of which the most important is the maintenance of an adequate oil supply to each part of the mechanism.



The helicopter engine test plant in an inclined position. The control room window can be seen in the lower right-hand corner of the illustration.

Since the staff of Alvis Limited, Coventry, are convinced that the shaft-driven helicopter is the type likely to be most successful in the future, they have recently installed new test beds for their engines. The most interesting of these is one which allows engines to be tested over a wide range of angles. The plant, constructed by Heenan and Froude, Limited, Shrub Hill, Worcester, permits the engine, with propeller shaft uppermost, to be swung from the vertical position through 90 deg. until it reaches the horizontal, or from the vertical up to 30 deg. in the opposite direction.

As will be seen from the illustration, the structure consists basically of two intersecting cylinders, each about 8 ft. in diameter, with their axes at right angles. The dynamometer and the engine under test are mounted at opposite ends of one of the cylinders and coupled together by means of a shaft passing through the centre of it. The other cylinder is arranged horizontally and has at each end a bearing track around its circumference; the whole assembly rests upon rollers carried by the supporting frameworks on either side of the engine room. A circular toothed rack fixed to one end of the horizontal cylinder is engaged by a pinion and driven through reduction gears by an electric motor. The motor can rotate the complete system and fix it at any angle in the 120 deg. range, the angle being clearly indicated by a large dial in the control room.

The whole building housing the engine room has been carefully designed to reduce noise and vibration to a minimum. The control room is carried on separate foundations and isolated from the rest of the building by means of anti-vibration joints. The room overlooks the test bed through a large observation window triple-glazed with armour-plate glass. The entire plant is operated from a large console in the control room, which is provided with various instruments including dial gauges for pressure and temperature measurements, and mercury manometers for the indication of engine boost, induction and supercharge pressures. The dynamometer and engine speeds are recorded by electrical tachometers, and the individual cylinder head temperatures are indicated by a multi-point pyrometer operating in conjunction with thermocouples. Quadrant levers on the console are connected through push-pull rods and twist shafts to the engine controls, electromagnetic clutches being interposed at suitable points to enable the angular position of the test bed to be altered without disturbing the control setting.

Sound-absorbent linings on the ceiling and walls of the engine room reduce the noise of testing within the building. Splitter panels in the air intake and exhaust tunnels minimise the level of sound reaching the outside.

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WATER SUPPLY FOR LIVERPOOL

The Liverpool Corporation Bill now before Parliament to construct a £20 million reservoir in the Tryweryn Valley, North Wales, has aroused strong Welsh opposition. There is some complaint about the methods of the field staff on the Parliamentary surveys in the valley—one is reminded of the old railway days and moonlight surveys of the estates of landowners! If the Bill goes through, the small hamlet of Capel Celyn would be displaced, to be rebuilt, in style, higher up, Liverpool promises; about 800 acres would be submerged, leaving little but poor hill pasture to the valley farmers—to whom Liverpool promises full reinstatement elsewhere. Nevertheless nationalist sentiment has been thoroughly aroused by the invasion of a traditional stronghold of Welsh language and culture.

The Tryweryn site is a rock basin, the best of eleven examined by the consulting engineers. Early on the opposition made some dubious suggestions as to other sites, and opinion also favoured a general treatment of Welsh water and a Welsh Water Board was suggested. Eventually the accepted direct alternative was the so-called " Pownall Grid Plan," this being a section, located mainly in Lancashire, of the general water grid outlined in an article, " The Grand Contour Canal," in ENGINEERING for December 11, 1953. Water would be gathered from West Pennine catchments near Lonsdale and distributed regionally, the canal line passing near Liverpool's reservoirs at Rivington. The plan has support on Liverpool City Council.

The promotion of an instalment of a national water grid would of course raise wide issues. Self-help in water supply worked well for long and still does in less populated areas. Nevertheless the larger supply undertakings are increasingly at cross purposes and their unco-ordinated spending may well prove more expensive than a unified plan. Regional interlinking would, as an immediate gain, reduce the hazard of reservoirs draining right down causing separate undertakings to provide extra local reservoir capacity. As regionally organised, the great ground-water reserves would be at call for extreme drought, permitting the artificial replenishment of the great range of aquifiers found in this country.

A national scale of bulk water delivery, besides meeting the west-east inequality of rainfall and drought incidence, would utilise the staggered effect of rainfall. As to possible forms of such a work, there are the pipeline grid as advocated by the late Mr. Alan Chorlton, M.P., and the contour canal, and also the pressure tunnel which as yet has not found advocates.

The field of water supply is certainly alive with suggestions to which professional engineers are hardly responding. In spite of much discussion on the artificial replenishment of aquifiers, no one seems willing to take the plunge with a large pioneer installation or, on wider issues, to argue out the " grid " or the coming vast irrigation demand which is already a newspaper topic. Perhaps the Welsh opposition are doing public service in forcing such issues into debate.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *December 28, page 825; or January 25, page 126. Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Leipzig International Fairs.—*Spring Fair and Technical Fair:* Sun., Mar. 3, to Thurs., Mar. 14, at Leipzig. *Autumn Fair:* Sun., Sept. 1, to Sun., Sept. 8, at Leipzig. *Agents:* Leipzig Fair Agency in Great Britain, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

Smallwares Trade Fair.—Mon., Mar. 4, to Fri., Mar. 8, at the Metropole Hotel, Brighton. Organised by Trade and Technical Exhibitions Ltd., 1 Dorset Buildings, Salisbury-square, London, E.C.4. Tel. FLEet Street 1555.

***Retail Management Conference.**—Tues., Mar. 5, to Thurs., Mar. 7, at Eastbourne. Organised by the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

Agricultural Machinery Exhibition, 28th International.—Tues., Mar. 5, to Sun., Mar. 10, at the Porte de Versailles ground, Paris. Held in conjunction with the General Agricultural Competition, at the same place. Apply to the Union des Exposants de Machines et d'Outillage Agricoles, 95 Rue Saint-Lazare, Paris 9e.

Copenhagen International Fair.—*Technical Fair:* Tues., Mar. 5, to Wed., Mar. 13. *Commercial Fair:* Sat., Mar. 23, to Sun., Mar. 31. In Copenhagen, Denmark. Organised by the International Messe, Vester Farimagsgade 6, Copenhagen V, Denmark. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

Ideal Home Exhibition.—Tues., Mar. 5, to Sat., Mar. 30, at Olympia, London, W.14. Organised by Associated Newspapers Ltd., 161-163 Queen Victoria-street, London, E.C.4. Tel. FLEet Street 6000.

Western Kenya Agricultural Show.—Fri. and Sat., Mar. 8 and 9, at Endoret, Kenya. Organised by the Royal Agricultural Society of Kenya, The Show Ground, P.O. Box No. 500, Nakura, Kenya.

Cologne Fairs.—*Spring Fair: Hardware and Household Goods:* Fri., Mar. 8, to Mon., Mar. 11; and *Clothing and Textiles:* Sun., Mar. 17, to Tues., Mar. 19, at Cologne. *Autumn Fair: Hardware and Household Goods:* Sat., Sept. 7, to Mon., Sept. 9; and *Clothing and Textiles:* Sun., Sept. 15, to Tues., Sept. 17, at Cologne. *Agent:* M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel.: WHItehall 8211.

Frankfurt International Fairs.—*Spring Fair:* Sun., Mar. 10, to Thurs., Mar. 14, at Frankfurt. *Autumn Fair:* Sun., Sept. 1, to Thurs., Sept. 5, at Frankfurt. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

Vienna International Fairs.—*Spring Fair:* Sun., Mar. 10, to Sun., Mar. 17, in Vienna. *Autumn Fair:* Sun., Sept. 8, to Sun., Sept. 15, in Vienna. *Agents:* British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

Junior Engineers' Meeting.—Mon., Mar. 11, to Thurs., Mar. 14, at Chester and Manchester. Organised by the Iron and Steel Engineers Group of the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061.

Atomic Exposition and Nuclear Congress, International.—Mon., Mar. 11, to Fri., Mar. 15, at the Convention Hall, Philadelphia. Coordinated by the Engineers' Joint Council, 29 West 39th-street, New York 16. Apply to Mr. H. F. Grebe, International Atomic Exposition, 117 South 17th-street, Philadelphia 3, Pa., U.S.A.

Motor Show, International.—Thurs., Mar. 14, to Sun., Mar. 24 in Geneva. Apply to the secrétariat général, Motor Show 1 Place du Lac, Geneva, Switzerland.

Kansas City, International Trade Fair.—Sun., Mar. 17, to Sun. Mar. 24, at Kansas City. Apply to Mr. L. L. Bratschie, Heaft of America International Trade Fair, Inc., 3230 Broadway, Kansas City 11, Missouri, U.S.A.

***Corrosion of Metals in Buildings, Symposium.**—Thurs., Mar. 21, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Organised by the Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. Tel. BELgravia 3681.

***Planning for Industry: Northern Conference.**—Fri., Mar. 22, to Sun., Mar. 24, at Southport. Organised by the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

Photographic Exposition, International.—Fri., Mar. 22, to Sun., Mar. 31, at the National Guard Armory, Washington. Apply to Mr. R. J. Wilkinson, International Photographic Exposition, 104 East Michigan-avenue, Jackson, Michigan, U.S.A.

Finnish Industries Spring Fair.—Fri., Mar. 22, to Sun., Mar. 31, at Helsinki. Organised by the Finnish Fair, Mannerheimintie 17, Helsinki, Finland.

Physical Society's Exhibition of Scientific Instruments and Apparatus.—Mon., Mar. 25, to Thurs., Mar. 28, in the Royal Horticultural Society's Old and New Halls, Vincent-square and Greycoat-street, London, S.W.1. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Western Metal Congress and Exhibition.—Mon., Mar. 25, to Fri., Mar. 29, in the Pan Pacific Auditorium, Los Angeles, California. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

***Electronics Exhibition.**—Tues. and Wed., Mar. 26 and 27, at the College of Science and Technology, Manchester. Organised by the North Western Radio and Telecommunications Group of the Institution of Electrical Engineers. Apply to the hon. secretary of the Group: Mr. J. Willis, College of Science and Technology, Sackville-street, Manchester. Tel. Central 3266.

***Synthetic Rubber, International Symposium on.**—Tues., Mar. 26, to Thurs., Mar. 28, at Church House, Great Smith-street, London, S.W.1. Organised by *The Rubber and Plastics Age*, Gaywood House, Great Peter-street, London, S.W.1. Tel. ABBey 7447.

***Planning for Industry: Midlands Conference.**—Fri., April 5, to Sun., April 7, at Droitwich. Organised by the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

***Chemical Society's Anniversary Meetings.**—Tues., April 9, to Fri., April 12, at Cambridge. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

London Audio Fair.—Fri., April 12, to Mon., April 15, at the Waldorf Hotel, Aldwych, London, W.C.2. Organised, on behalf of Audio Fairs Ltd., by C. Rex-Hassan and Associates, 42 Manchester-street, London, W.1. Tel. WELbeck 9111.

United States World Trade Fair.—Sun., April 14, to Sat., April 27, at the New York Coliseum, New York. *Managers:* The Charles Snitow Organisation, Inc., 331 Madison-avenue, New York, 17. Information may be obtained from the British Commonwealth Chamber of Commerce in the United States, 677 Fifth-avenue, New York, 22; and from the Fair's British and Commonwealth Office, Dudley House, 36 and 38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

***Molecular Mechanism of Rate Processes in Solids, Conference.**—Mon., April 15, to Thurs., April 18, at the Royal Tropical Institute, Mauritskade, Amsterdam. Organised by the Koninklijke Nederlandse Chemische Vereniging. Apply to the Faraday Society, 6 Gray's Inn-square, London, W.C.1. Tel. CHAncery 8101.

Materials Handling Exposition, National.—Mon., April 29, to Fri., May 3, in the Convention Hall, Philadelphia. Apply to Clapp and Poliak Inc., 341 Madison-avenue, New York 17.

Factory Equipment Exhibition, Fifth.—Mon., April 29, to Sat., May 4, at Earl's Court, London, S.W.5. Theme: "Greater Efficiency in Industry." Organised by Factory Equipment Exhibitions, Ltd., 4 Snow-hill, Holborn-viaduct, London, E.C.1. Tel. CENtral 0354.

Health Congress.—Tues., April 30, to Fri., May 3, at Folkestone. Organised by the Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. Tel. SLOane 5134.

Office Equipment Exhibition.—In May, at Tokyo. Organised by the Japan Office Management Association, 2/1 Ginzanishi, Chuo-ku, Tokyo.

***Planning for Industry: Scottish Conference.**—Fri., May 3, to Sun., May 5, at Gleneagles. Organised by the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

Caribbean Exhibition.—Fri., May 3, to Sun., May 19, at Port of Spain, Trinidad. Apply to the Junior Chamber of Commerce of Trinidad, Port of Spain, Trinidad.

Home Building Exposition, Second International.—Sat., May 4, to Sun., May 12, in the Coliseum, New York. Exposition offices: 250 West 57th-street, New York 19, U.S.A.

Japan International Trade Fair.—Sun., May 5, to Sun., May 19, at Harumi Pier Grounds, Harumicho, Chuo-ku, Japan. Apply to Fair Management Office, Tokyo International Trade Fair Commission, c/o Economic Bureau, Tokyo Metropolitan Government, Marunouchi 3-Chome, Chiyoda-ku, Tokyo, Japan.

Industrial Tool and Production Show of Canada.—Mon., May 6, to Fri., May 10, in the Industry Building, Exhibition Park, Toronto. Apply to Mr. E. M. Wilcox, 19 Melinda-street, Toronto, Canada. (Alteration of dates).

Engineered Castings Show, First; and the 61st A.F.S. Castings Congress.—Mon., May 6, to Fri., May 10, at Cincinnati Music Hall, Cincinnati, Ohio, U.S.A. Sponsored by the American Foundrymen's Society, Golf and Wolf-roads, Des Plaines, Illinois, U.S.A.

***Standards, Third Conference of Engineers Responsible for.**—Thurs., May 9, at Church House, Great Smith-street, London, S.W.1. Organised by the British Standards Institution, 2 Park-street, London, W.1. Tel. MAYfair 9000.

Midwest Automotive Trade Show.—Thurs., May 9, to Sun., May 12, in the Kiel Auditorium, St. Louis. Organised by the Midwest Automotive Trade Show, Inc., 2841 Locust-street, St. Louis 3, Missouri, U.S.A.

Tractor Show, International.—Sun., May 12, to Sun., May 19, in the Exhibition Building, Valentino Park, Turin, Italy. Organised by the Saloni Internazionale della Technica. Apply to the Agricultural Engineers Association, 6 Buckingham-gate, London, S.W.1. Tel. TATe Gallery 7973.

Office Machinery Exposition.—Mon., May 13, to Thurs., May 16, at Los Angeles, California. Organised by the National Office Management Association, 132 West Chelten-avenue, Philadelphia 44, Penn., U.S.A.

Protective Clothing and Safety Equipment Exhibition, First.—Mon., May 13, to Fri., May 17, at Olympia, London, W.14. Organised by the U.T.P. Exhibitions Ltd. (Associate company of United Trade Press Ltd.), 9 Gough-square, Fleet-street, London, E.C.4. Tel. FLEet Street 3172.

Packaging Exhibition.—Tues., May 14, to Tues., May 21, in the R.A.I. Building, Amsterdam. Organised by N.V. 't Raedthuys, 5 Tesselschadestraat, Amsterdam, Holland.

German Handicrafts and Trade Fair, International.—Wed., May 15, to Sun., May 26, at Munich. Organised by Verein für Handwerks-Ausstellungen und Messen e. V., Theresienhöhe 14, Munich 12, Germany.

***Aluminium in Electrical Engineering, Symposium.**—Thurs. and Fri., May 16 and 17, at the Institution of Electrical Engineers, Savoy-place, London, W.C.2. Organised by the Aluminium Development Association, 33 Grosvenor-street, London, W.1. Tel. MAYfair 7501.

***Pressure Die Casting Conference, International.**—Mon., May 20, to Fri., May 24, in Paris. Apply to the Zinc Development Association, 34 Berkeley-square, London, W.1. Tel. GROsvenor 6636.

***Yorkshire Building Trades and Public Works Exhibition.**—Tues., May 21, to Sat., June 1, at Woodhouse Moor Exhibition Site, Leeds. Organised by Modern Exhibition Services Ltd., 12 Finghall-road, Urmston, Manchester. Tel. URMston 3993.

Scottish Radio and Television Exhibition.—Wed., May 22, to Sat., June 1, at the Kelvin Hall, Glasgow. Organised by the Radio Industry Council, 59 Russell-square, W.C.1. Tel. MUSeum 6901.

Book Exhibition, Second International.—Sun., May 26, to Thurs., May 30, at Sherman Hotel, Chicago. *Agent:* Mr. A. P. Wales, Dudley House, 36–38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

***African Regional Road Congress.**—Mon., May 27, to Thurs., May 30, at Salisbury, Southern Rhodesia. Organised by Road Federations of East, Central and South Africa, with the co-operation of the London office of the International Road Federation, Abbey House, Victoria-street, London, S.W.1. Tel. ABBey 6177.

Waikato Agricultural Winter Show.—Tues., May 28, to Tues., June 4, in Hamilton, New Zealand. Apply to Mr. W. H. Paul, Box 616, Hamilton, New Zealand.

Bath and West Agricultural Show.—Wed., May 29, to Sat., June 1, at Swindon. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont-street, Bath. Tel. Bath 3010.

Electronics in Automation, Convention.—In June, at King's College, Cambridge. Organised by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. Tel. MUSeum 1901.

Printing Industries and Allied Trades, International Exhibition.—Sat., June 1, to Sun, June 16, in Lausanne. Offices: 6 Avenue Mon-Repos, Lausanne, Switzerland.

World Power Conference Sectional Meeting.—Wed., June 5, to Tues., June 11, followed by study tours. Trade Unions' Building, Belgrade, Yugoslavia. Apply to the British National Committee, 201 Grand Buildings, Trafalgar-square, London W.C.2. Tel. WHItehall 3966.

***Technical Writers' Institute, Convention.**—Mon., June 10, to Fri., June 14, at the Rennsselaer Polytechnic Institute, Troy, New York, U.S.A. Organised as an aid to the profession of technical writing. Apply to Mr. Jay R. Gould, Director, at the above address.

Three Counties Agricultural Show.—Tues., June 11, to Thurs., June 13, at Hartpury, Gloucester. Organised by the Three Counties Agricultural Society, Berrington House, 2 St. Nicholas-street, Hereford. Tel. Hereford 3969.

Safety and Factory Efficiency Exhibition.—Fri., June 14, to Fri., June 21, at Bingley Hall, Birmingham. Organised by Birmingham and District Industrial Safety Group, Industrial Safety Training Centre, 22 Summer-road, Birmingham 27.

Atomic Energy Exhibition, International.—Sun., June 16, to Sat., Aug. 31, at Schiphol Airport, near Amsterdam, Holland. Organised with the support of the Dutch Government, the Amsterdam City Council, and the Amsterdam Chamber of Commerce. Secretariat offices: 37 Roemer Visscherstraat, Amsterdam. *Agents:* Galitzine and Partners Ltd., 17 Victoria-street, London, S.W.1. Tel. ABBey 4013.

Electrical Power Convention Exhibition.—Mon., June 17, to Fri., June 21, at Devonshire Park, Eastbourne. Organised by the British Electrical Development Association, 2 Savoy-hill, London, W.C.2. Tel. TEMple Bar 9434.

***Internal-Combustion Engine Congress, Fourth International.**—Mon., June 17, to Sat., June 22, at Zürich. Theme: "Supercharged Diesel Engines and Combustion Turbines in Various Spheres—Marine, Traction and in Power Stations." Apply to Mr. C. C. M. Logan, secretary, British National Committee, 6 Grafton-street, London, W.1. Tel. HYDe Park 5107. See ENGINEERING, December 2, 1955, page 753. (Additional particulars.)

Business Efficiency Exhibition.—Mon., June 17, to Thurs., June 27, at Olympia, London, W.14. Organised by the Office Appliances and Business Equipment Trades Association, 11-13 Dowgate-hill, Cannon-street, London, E.C.4. Tel. CENtral 7771.

***Welding Conference, British Commonwealth.**—Mon., June 17, to Sat., June 29, in London and at Saltburn-by-the-Sea. Organised by the Institute of Welding, 29 Park-crescent, London, W.1. Tel. LANgham 7488.

Commercial and Scientific Exhibition.—Mon., June 24, to Wed., June 26, at the Show Mart, Montreal. Held in conjunction with the 23rd Congress of the Catholic Hospitals of the Province of Quebec. Apply to the Comité des Hôpitaux de Quebec, 325 Chemin Sainte-Catherine, Outremont, Montreal 8, Canada.

Exchange of Management Information, 11th International Conference.—Mon., June 24, to Fri., June 28, in Paris. Apply to the British Institute of Management, 8 Hill-street, London W.1. Tel. GROsvenor 6000.

Housewares Show, Second International.—Mon., June 24, to Fri., June 28, in the Coliseum, New York. Organised by the Housewares Shows Corporation, 19 West 44th-street, New York 36, U.S.A.

Bond and Crack Formation in Reinforced Concrete, RILEM Symposium.—Thurs., June 27, to Sun., June 30, in Stockholm. Apply to the organising secretary, RILEM Symposium, c/o Cement and Concrete Institute, Stockholm 70, Sweden.

***Electronics in Automation, Convention.**—Thurs., June 27, to Mon., July 1, at the University, Cambridge. Organised by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. Tel. MUSeum 1901.

Indonesia International Trade Fair.—Thurs., June 27, to Tues., Aug. 6, at Surabaya. Organised by the National Board of Indonesian Exhibitions, P.O. Box No. 2444, Djakarta, Indonesia.

***Concrete Shell Roof Construction, Second Symposium on.**—Mon., July 1, to Wed., July 3, at the Ingeniorenes Hus, Oslo, Norway. Organised by the Norwegian Engineering Society in co-operation with the Norwegian Concrete Association. Apply to the Cement and Concrete Association, 52 Grosvenor-gardens, London, S.W.1. Tel. BELgravia 6661.

***Occupational Health, Twelfth International Congress on.**—Mon., July 1, to Sat., July 6, at Helsinki. Apply to the secretary, organising committee, Haartmaninkatu, 1, Helsinki, Finland.

***Solvent Effects and Reaction Mechanism, Symposium.**—Mon. and Tues., July 8 and 9, in the Queen's Building, Queen Mary College, London, E.1. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Atoms Exhibition.—In August, at Geneva. Address of organising committee: 1 Place du Lac, Geneva, Switzerland. See ENGINEERING, December 16, 1955, page 816.

***Soil Mechanics and Foundation Engineering, International Society of: Fourth International Conference.**—Mon., Aug. 12, to Sat., Aug. 24, in London. Apply to the Society's secretary, Mr. A. Banister, Institution of Civil Engineers, Great George-street, London, S.W.1. Tel. WHItehall 4577.

***Motor Industry Eleventh Annual Summer School.**—Sat., Aug. 24, to Sat., Aug. 31, at St. Catherine's College, Cambridge. Organised by the Institute of the Motor Industry, 40 Queen's-gate, London, S.W.7. Tel. WEStern 0915.

***Farnborough Flying Display and Exhibition.**—Mon., Sept. 2, to Sun., Sept. 8, at Farnborough, Hampshire. Open to the public on Fri., Sat. and Sun., Sept. 6, 7 and 8, only. Organised by the Society of British Aircraft Constructors Ltd., 29 King-street, London, S.W.1. Tel. TRAfalgar 3231.

***British Association Meeting.**—Wed., Sept. 4, to Wed., Sept. 11, in Dublin. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109.

***Workmen's Safety and Factory Hygiene Congress and Exhibition.**—Thurs., Oct. 17, to Sat., Oct. 19, at Düsseldorf. Sponsored by the German Society for Workmen's Safety. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany.

In Parliament

FINANCING RESEARCH

Sums spent in Britain on scientific research and development were briefly discussed in the House of Commons last week. Mr. Bernard Braine (Conservative), who raised the matter, asked the Chancellor of the Exchequer for information regarding the proportion of the gross national product spent by the Government and by private industry on these activities, excluding market research and capital development, in 1939, 1950 and 1955. He pointed out that there was a definite established correlation between investment in research and an increase in national productivity. In the United States there was a far greater investment in scientific research and, consequently, far greater results. In view of these facts, relief should be provided in the coming Budget for such investigations.

The Financial Secretary to the Treasury, Mr. J. Enoch Powell, told the House that the proportion of the gross national product spent on scientific research and development work in 1955 was estimated at about 2 per cent. Between one-third and one-half of this work was done in Government laboratories or by the nationalised industries, and a large part of the remainder was financed by the Government. There were no estimates in respect of 1939 and 1950. On the broader issue, the Advisory Council on Scientific Policy was considering the whole question of the extent to which the country's resources were being devoted to activities of this kind. The results of the investigation "would be forthcoming."

Later, Mr. Powell announced the setting up, by the Government, of a National Institute for Research in Nuclear Science, a reference to which is made in this week's Atomic Review.

D.S.I.R. HELP BUILDING

It transpired from a parliamentary answer to Mr. F. T. Willey (Labour) that the total staff of the Department of Scientific and Industrial Research numbered 4,575 on January 1 last. Speaking as the representative in the House of Commons of the Lord President of the Council, Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, assured the House that the Marquess of Salisbury was well aware of the importance of securing an adequate and efficient staff, in order to maintain the progress of the Department, and that recruiting was being carried out with the greatest possible speed.

With regard to the co-operation of the Department in the work of other countries, it was in direct collaboration with the European Productivity Agency of the Organisation for European Economic Co-operation in the preparation of material for conferences on automation and the adaptation of the job to the worker, and on five projects connected with aspects of building practice. These projects concerned modular co-ordination, prefabrication in house building, methods of organisation on building sites, the mechanisation of certain building operations, and the production and distribution of concrete at building sites. In addition, the Department was collaborating with seven overseas countries in a research project on the preparation of fresh water from salt water.

The Minister agreed with Mr. Willey that such collaboration was one of the most effective forms of European co-operation. There were many other projects, with which the Department was associated, that had been initiated by the O.E.E.C., and that had resulted in internation co-operation.

LECTURES ON TECHNICAL SUBJECTS

In the House of Lords, the Earl of Craven (Conservative) asked whether the Government were providing lectures on technical subjects in order to educate persons in industry and transport in the needs for modern techniques which would cut prices, provide more trade and increase prosperity.

Viscount Hailsham, the Minister of Education, pointed out that it was the policy of the Government to encourage and assist local education authorities and other bodies, such as the British Productivity Council, to carry out this work. The Council, which was assisted by Government grants, conducted and promoted a number of activities, including lectures and demonstrations, designed to spread interest in, and a knowledge of, modern techniques.

So far as technical colleges were concerned, every effort was made to keep their courses up to date at all levels for students working for their initial qualifications, in order to make them familiar with modern techniques. A wide variety of short courses was provided for scientists, technologists and senior executives of all kinds holding responsible posts in industry. As the expansion announced in the White Paper on *Technical Education* (Cmd. 9703, H.M.S.O., 1*s.* 9*d.*) proceeded, a considerable increase in the number of these courses was to be expected.

WELSH AFFAIRS

A general debate on matters relating to Wales was initiated by Mr. Henry Brooke, the Minister of Housing and Local Government and Minister of Welsh Affairs, who referred to the welcome which had been given to the new arrangement whereby Welsh affairs were combined with the Ministry of Housing and Local Government, instead of with the Home Office.

The Rev. Llywelyn Williams (Labour) said that Labour members would welcome the principle of a Secretary of State for Wales with cabinet rank, and the creation of a Welsh Office with four Departments of State. He felt that more use should be made of Welsh ports, which had proved their worth during the war. Ships were allowed to wait for berths at other ports when facilities at Cardiff, Newport, Barry and Swansea were available. A private Bill had been introduced by the Liverpool Corporation to impound the waters of the Tryweryn Valley and to construct a huge reservoir there. It was undesirable that large corporations should be able to proceed in this way, which enabled them to ignore local feeling and interest. Corporations should proceed by means of an Order.

On this point, Mr. Brooke said that he had written to the Council of Wales and Monmouth stating that he thought to set up a committee to advise him on matters connected with the conservation and use of water resouces in the Principality. He was arranging for water engineers to begin an investigation immediately.

FINANCE BY TOLLS

Mr. Williams regretted that it had been decided to proceed with the Forth Bridge instead of the Severn Bridge, which had been regarded as a number one priority since 1947. Although previously opposed to the toll system advocated by the Severn Bridge Authority, he had been compelled to modify his standpoint in view of the realisation that the Severn Bridge would remain a pipe dream for a very long time unless it could be financed by this means.

In reply to a question by Mr. James Griffiths (Labour), who stated that there were differing views in the Labour Party regarding the institution of tolls, Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, said that he had made it clear that none of these very large bridge projects could be considered, in the present circumstances, unless they were paid for by means of tolls. Later, Mr. Brooke pointed out that the Severn Bridge would cost at least £30 million and was included in a future programme, and that he understood that the Minister of Transport had agreed with the local authorities concerned that it should be constructed on a toll basis.

STANDARDS FOR FARM MACHINERY

A plea was put forward by Mr. George Jeger (Labour) that the Ministry of Agriculture, Fisheries and Food should take further steps to encourage greater efficiency and economy in agriculture by securing a larger measure of standardisation of spare parts for agricultural machinery. He pointed out to the Minister that the work of standardising farm machinery was proceeding exceedingly slowly and that many farmers were concerned about the lack of standardisation, even for such simple parts as nuts and bolts.

In reply, Mr. Derick Heathcoat Amory said that faster progress in matters of this kind was always being hoped for, and the Agricultural Machinery and Implements Industry Standards Committee had been studying this matter, with the result that the British Standards Institution had issued twelve standards for tractors and agricultural machinery, which had been adopted by many manufacturers. He was assured that there were very great technical difficulties, but work on other standards was proceeding.

Future of the E.L.M.A.

Mr. George Jeger (Labour) asked the President of the Board of Trade whether he was aware of the decision of the Electric Lamp Manufacturers Association to dissolve itself, and whether he would take action to induce similar associations to take the same step. Mr. Derek Walker-Smith, Minister of State to the Board of Trade, replied that he had seen reports that the E.L.M.A. was to be dissolved. It was one of the objects of the registration procedures of the Restrictive Trade Practices Act to induce industry to review its restrictive trading arrangements.

Unemployment in Engineering

The Minister of Labour and National Service, Mr. Iain Macleod, told the House that he was aware that there had been some increase in unemployment in the engineering industry in the West of Scotland. Most of the increase, he informed Mr. W. Ross (Labour), was due to the completion of new vessels on the Clyde and was expected to be of a temporary nature only. He understood that a number of redundancies were likely to occur shortly at two firms in the area, one of which manufactured aircraft and the other motor vehicles. With respect to the Dumbarton aircraft factory of the Blackburn Aircraft Company, Limited, about 250 employees were expected to be discharged shortly. As soon as it was known which workers were to be affected, the services of local offices of his Ministry, he told Mr. Tom Steele (Labour), would be available to help such persons to obtain other employment.

Workers' Greater Buying Power

Mr. Macleod said that statistics relating to the total incomes of industrial employees were not available, but inquiries regarding the average weekly earnings of manual wage earners in the manufacturing industries generally, and in a number of the principal non-manufacturing industries, showed that there had been a rise of 45 per cent. between April, 1951, and April, 1956. The index of retail prices, during this period, rose by 30 per cent. The Minister told Mr. Henry A. Price (Conservative) that he was unable to say how much of the rise in prices could be attributed to the increase in earnings, or what the average rise in prices would have been if the earnings of these manual workers had improved by only 30 per cent.

Pound Buys Less

Particulars of the purchasing power of the pound sterling at various recent dates were given by Mr. Nigel Birch, the Economic Secretary to the Treasury, in answer to questions put forward by Mr. A. W. J. Lewis (Labour). He said that the pound's purchasing power, taken at 20*s.* in 1945, was estimated at 20*s.* in September, 1946; 15*s.* 6*d.* in October, 1951; 14*s.* 6*d.* in October, 1952; 13*s.* 7*d.* in April, 1955; and 12*s.* 7*d.* in December, 1956. These figures were based on the cost of living and the retail price indexes.

Put in another way, the purchasing power of the pound had declined by over one-sixth since October, 1951. This transpired from another answer by the Treasury's Economic Secretary to Mr. Lewis. In this reply, Mr. Birch gave the month-by-month figures showing how the value of the pound, taken as worth 20*s.* in October, 1951, had fallen to only 16*s.* 3*d.* by December last.

THE HUMAN ELEMENT

Masters in their Own House

The substantial majority for strike action produced by the ballot held among members of the Amalgamated Engineers Union last week has confirmed the feelings among trade unionists that the principles at stake in the dispute were too important to permit the union to let the matter drop. Ford have said that they will have industrial discipline at their plants "at any price." The A.E.U. feel that, likewise, they must uphold their member's rights if in their opinion he is the victim of circumstances rather than of his own indiscipline. That this belief is widely held was shown by a resolution passed by the trade union side of the Ford national joint negotiating committee, expressing "unanimous dissatisfaction" with the management's decision not to reinstate the dismissed shop steward, Mr. J. McLoughlin. The 21 unions concerned state in the resolution that they consider the demand for reinstatement as a "very reasonable proposal."

The A.E.U's decision to call a strike on Wednesday, February 27, was taken without reference to the other unions and before the meeting with Sir Wilfred Neden, chief industrial commissioner to the Ministry of Labour. The main chance of settlement now lies in a meeting of both sides after each has talked to the Ministry. The decision to call a strike is believed to have been taken very reluctantly by the A.E.U. executive: so much so, that a compromise may well emerge later this week.

Neither the unions with short-time and unemployment generally throughout the industry, nor the management with the spring demand for cars developing, can want a trial of strength. The wish to come to terms is there, but the parties have left themselves precious little room to manoeuvre, and now very little time.

While the wish of the Ford management to be masters in their own house must be respected it is difficult not to look back on the history of Briggs and to conclude that much more remains to put right than the elimination of a single shop steward, or even of a whole committee.

Wage Scales and Arpeggios

Employers have rejected the building workers' wage claim and the railway workers have done the same to the British Transport Commission's offers of 3 and 3½ per cent. increases. In both cases negotiations are to be taken a step further towards arbitration, where they are likely to end up.

Building employers' representatives considered that they could not afford to add further to their costs at a time when credit restriction limited building, the prices of materials and transport had increased and rates were to advance by 1*d.* an hour. The National Federation of Building Trades Operatives have referred their claim for a 4*d.* per hour increase to a sub-committee of the industry's national joint council. The workers' case rests on their assertion that 1*d.* an hour does not compensate for the whole rise in living costs since their last increase, and that the employers can quite easily meet the 4*d.* claim out of profits.

The Transport Salaried Staffs' Association rejected an offer of 3 per cent. for the 100,000 salaried workers on British Railways, claiming that what is needed is a complete revision of salaries and the establishment of a cost-of-living sliding scale. The National Union of Railwaymen rejected the B.T.C.'s offer for a 3½ per cent. increase and are pressing their claim for 10 per cent., which will be heard by the Railways Staff National Tribunal later this month. It seems likely that both claims will be vigorously pursued. The T.S.S.A. feel they have been shabbily treated and that the B.T.C. take advantage of their moderate attitude. Gradually the railway unions are being drawn closer together. The difficult situation which appears to be developing in an industry where labour-management relations are traditionally good could make the task of increasing efficiency very difficult for the B.T.C. despite heavy investment in plant and equipment.

Civil Persuasion

The Institution of Civil Engineers have put out an attractive leaflet on their profession called "Civil Engineering—a creative career." They have supported it with a singularly inept press release which will fortunately not be seen by those for whom the leaflet is intended. Why, as the handout suggests, anyone thinking of "entering on a creative career in literature or painting" should consider civil engineering is difficult to imagine. Let the issue be squarely faced. Anyone who starts to qualify as a civil engineer faces an intellectual and physical discipline which would appeal to few artists or authors. Their disciplines are real enough but they are of an entirely different kind.

The leaflet, designed for circulation around schools and with its emphasis on opportunity and enterprise, is on much better ground. There is a mass of ignorance about what an engineer is and does. In an age of wide educational opportunities, when the profession is opening up to able youngsters of limited means, it is vital that they should be shown how they can achieve the highest qualifications. If that is not done, too many will get syphoned off at the lower technical and engineering operative levels. These are equally important but they could yet be brought to full strength while there existed a severe lack of qualified men at the top to do the thinking and to lead.

None of the other professions is seriously troubled by the misuse of their professional title. They have put their professional, organised weight behind a continuous effort to keep clear the meaning of the word accountant, doctor or solicitor. No one thinks that a solicitor is anyone who solicits. Only bankers are in the same dilemma as engineers and they have never been a profession to the same degree. An educational drive is much overdue.

High Tension

The Central Electricity Authority and the Electrical Power Engineers' Association have reached deadlock in their dispute over technical staff salaries. The matter took an ugly turn last week for a short time when instructions to members of the association were prepared telling them to work to rule. Cooler heads prevailed, however, and the association in the end agreed to refer the issue to the Ministry of Labour. Just before the meeting, however, their general secretary, Mr. H. Norton, made it clear that the E.P.E.A. were determined to secure their objective and that they did not intend to go back "into the fruitless negotiation machinery."

The dispute centres on differentials of pay. The union claims that it has been negotiating for a restoration of the 1948 differentials since November, 1955. Lord Citrine said last week that the claim was rejected finally and decisively in January, 1956. Negotiations had been taking place on other matters for some time and these have broken down on the question of charge engineers' salaries. Lord Citrine has said categorically that the C.E.A. is prepared to negotiate on salaries but it will not open up the question of differentials.

An impression is given from the way this dispute has gone in recent weeks that the problem is one of frayed tempers rather than differentials. In that case it is as well to let the Ministry act, for electric power is not a matter which the country can afford to trifle with.

Elected though Committed

In a close contest and small poll Mr. C. W. Hallett, one of the assistant secretaries of the A.E.U. has been elected as general secretary. He received only 242 votes more than Mr. J. M. Boyd and outside opinion would have favoured the chances of the latter. It seems that the victor attracted a certain number of Communist votes for tactical reasons. The Communist candidate went out at the first ballot last October and the party following were able to take a long-term view of their interests in the issue. No doubt, in the end, they decided that it would suit them better to vote for the older man and accordingly supported the 56 year old Mr. Hallett. Mr. Boyd is only 38 and could have looked forward to a long tenure of office.

One of the interesting side issues of the election is that Mr. Hallett has been concerned of late with the joint negotiating committee at Ford's. He therefore assumes office at a time when his union is concerned in an exceedingly difficult management-labour problem and one in which he is at the tactical disadvantage so far as his new post is concerned of not being able to adopt an uncommitted attitude. Mr. Hallett has been a member of the union for 40 years. The dispute at Briggs is going to give him every opportunity to use his long experience to good advantage.

The A.E.U. now has new men at the top, for Mr. Carron has not been president of the union for very long. They have taken on critical jobs in the trade-union world. To-day, more than ever before, the climate of management-labour relations in the engineering industry is critical for British industry as a whole.

Plea for a Sovereign T.U.C.

A trade union leader has suggested a radical change in the functions of the Trades Union Congress. There is a need, he argued, for a single negotiator backed by the full power of the trade union movement to match the weight of the Government departments and the national employers' organisations. The present structure of the movement should therefore be changed to allow the T.U.C. to negotiate in wages and working conditions.

This plea made last week by Mr. Alan Birch in an address to the Manchester Statistical Society entitled "The Structure of the British Trade Union Movement." Mr. Birch is general secretary of the Union of Shop, Distributive and Allied Workers and a member of the T.U.C. General Council. In addition to playing a more active role in negotiations, the T.U.C. should act as a general staff to co-ordinate policy and "to reconcile the needs of the unions, with general principles appropriate to the times." It is there that Mr. Birch treads on dangerous ground that has proved the graveyard of a number of the more daring trade unionists (and employers) of the post war era. He dares suggest in public what is in everyone's mind—namely that existing machinery of collective bargaining, industry by industry, is unable to take sufficient account of the relationship of wages, costs and prices "viewed from the national standpoint." He adds, "The more it becomes a feature of the trade union's policy to advocate changes in the nation's industrial and social relationships, the more it is incumbent on the trade unions to envisage the part to be played by them in that changed environment."

Well, well . . . the Chancellor didn't say it, but he may well quote Mr. Birch in his reply to the T.U.C.'s memorandum on the forthcoming Budget.